A Prospective Study of

FUNCTIONAL OUTCOME OF DISPLACED FRACTURES OF THE PROXIMAL HUMERUS MANAGED SURGICALLY

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CERTIFICATE

This is to certify that this dissertation in **"PROSPECTIVE STUDY OF FUNCTIONAL OUTCOME OF DISPLACED FRACTURES OF THE PROXIMAL HUMERUS MANAGED SURGICALLY"** is a bonafide work done by **Dr. A. SRINIVASAN** under my guidance during the period 2004 – 2007. This has been submitted in partial fulfillment of the award of **M.S.** Degree in **Orthopedic Surgery (Branch – II)** by the Tamilnadu Dr. M.G.R. Medical University, Chennai.

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DECLARATION

I, **Dr. A. SRINIVASAN,** solemnly declare that the dissertation titled **"A PROSPECTIVE STUDY OF FUNCTIONAL OUTCOME OF DISPLACED FRACTURES OF THE PROXIMAL HUMERUS MANAGED SURGICALLY"** was done by me at The Government Royapettah Hospital, Chennai – 14, during 2004-2006 under the guidance of my unit chief **Prof. K. NAGAPPAN, M.S(Ortho), D. Ortho.**

The dissertation is submitted in partial fulfillment of requirement for the award of M.S. Degree (Branch – II) in Orthopaedic Surgery to **The Tamil Nadu Dr. M.G.R. Medical University.**

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CONTENTS

INTRODUCTION

Fractures of Proximal Humerus are challenging for diagnosis and treatment. They are not uncommon, accounting for 4 to 5% of all fractures[1,2,3,4,5,6]. 80-85% of these fractures are minimally displaced or undisplaced and are effectively treated symptomatically with immobilisation followed by early motion[4,7,8,9]. Proximal Humerus Fractures are the third most frequent fracture in elderly patients after hip fracture and Colles fracture[10]. It is important to recognise these fractures early. Results and Treatment of the most severely displaced Fractures of the Proximal Humerus have not been consistently satisfactory when treated with non-operative measures[4,11,12]. If neglected they may result in pain, stiffness, arthritis, loss of muscle power and function.

Fractures of Proximal Humerus have gained more attention recently. Diagnosis has been facilitated with adaptation of 3-right angled trauma series X-rays [2,13,14,15] supplemented with CT or MRI. With more standard use of Neer's 4-part Classification system for fracture and fracture dislocation[16,17,18], a protocol for management and comparison of long term outcome of similar injuries has been made possible.

Emphasis is placed on complete and accurate diagnosis and formulation of safe and simple techniques for fracture realignment,

restoration of stability, fracture healing, cuff integrity, regaining motion and function.

There have been improvements in fixation techniques and in the understanding of the role of prosthetic replacement[19,20,21,22], to maximise anatomic restoration and minimising immobilisation time, during which stiffness develops.

The elderly no longer need to be denied effective surgical treatment, especially at a time in life, when the shoulders are often needed for ambulation with canes and crutches. Maintenance of good shoulder function may make a good difference to their independent life style.

In this study we have analysed the functional outcome of 20 cases of displaced fractures of Proximal Humerus managed surgically.

AIM OF THE STUDY

Prospective study of Functional outcome of displaced fractures of the Proximal Humerus managed surgically at the Department of Orthopaedics and Traumatology, Govt. Royapettah Hospital, Royapettah, Chennai between May 2004 and September 2006.

REVIEW OF LITERATURE

Historical Review

Hippocrates is credited with documenting the fracture of Proximal Humerus first in 460 BC. He also described a method of weight traction that aided bone healing.

However, little was written about this subject until the later part of the 19th century.

In 1896, Kocher developed an anatomic classification in an attempt to improve diagnosis and treatment but this simplified scheme was not descriptive enough and lacked consistency.

The first prosthetic arthroplasty of the shoulder is credited to Pean in 1893[23]. He described replacement of proximal part of the humerus with a platinum and rubber prosthesis in a young man who had TB that involved Glenohumeral joint.

In early 20th century, various methods of closed reduction, traction and abduction splints were developed to maintain alignment of these fractures with inconsistent results.

In 1932, Roberts reported that the use of an elaborate apparatus and prolonged immobilisation was less satisfactory than treatment with simpler forms of fixation and early motion. Open

reduction of severely displaced fracture dislocations gained popularity during the same period, in an effort to provide better anatomic alignment and function.

In 1934, Codman made a significant contribution by dividing Proximal Humerus fracture into 4 parts namely, Head, Lesser Tuberosity, Greater Tuberosity and Shaft along old epiphyseal lines or scars. This became the basis of Neer's four part classification.

In 1949, Widen first reported on Intramedullary Nailing of transcervical fractures and credited Palmer with the development of the technique.

The use of humeral head prosthesis for fractures of Proximal Humerus was first reported in the early 1950's.

In 1950, Rush described his methods of Intramedullary Nailing which later became popular as Rush pins.

The original Neer I Prosthesis was designed in 1951.

In 1955, Neer reported good results with the use of metal humeral head prosthesis in 27 patients with dislocation[23,24].

In 1970, Charles Neer of Newyork proposed his classic 4 part classification based on Codman's 4 parts.

In early 1970's AO ASIF group popularised the use of AO plates and screws for displaced fractures and fracture dislocations.

In 1972, Bichel designed a Total Shoulder Prosthesis of the ball and socket type[25]. In 1972 the Stanmore Total Shoulder Replacement also a Ball and Socket design was developed for patients with Rhematoid Arthritis[25].

In 1973, the original Neer I prosthesis was revised by Neer, as Neer II prosthesis, to improve the results.

Newer prosthesis like Grammont reverse shoulder prosthesis has been designed for even better function.

Percutaneous pinning and minimal fixation have now become the order of the day with principles of biological fixation.

Recently, a new concept has evolved in treating osteoporotic fratures. Fixed angle stable locking plates have been developed which lock screws to the plate and hence forms fixed angle construct.

ANATOMICAL CONSIDERATIONS

Developmental Anatomy

The primary ossification centre for humerus appears as early as 6th week of foetal life. In infants Proximal Humeral epiphysis is spherical [2,26]. There are three centre of ossification [2,27]. The central or major centre of ossification appears between 4-6 months of life. The centre for greater tuberosity appears at three years and that for lesser tuberosity appears by five years. These coalesce between 4 and 6 years and close between 18 and 20 years [2,26,27,28].

Relevant Anatomy

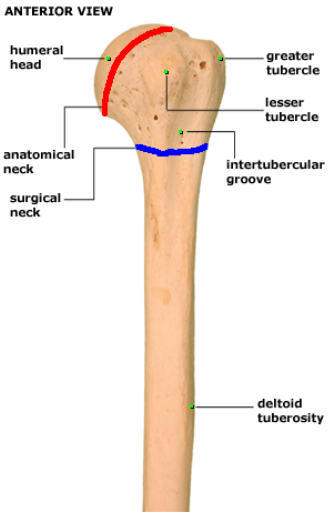
It is important to understand the complex anatomy of shoulder because optimum function of humeral joint is dependant on proper alignment and interaction of its anatomical structure .

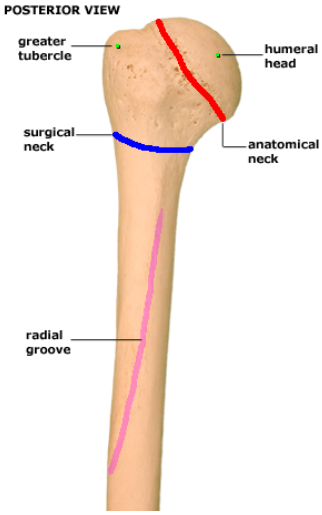
Humerus is the longest and largest bone in the arm. It has an expanded proximal end called "PROXIMAL HUMERUS", a shaft and distal end.

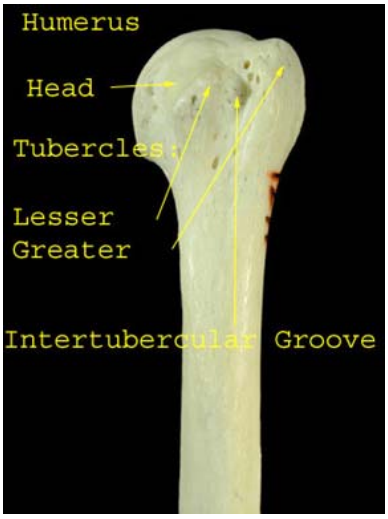
The proximal Humerus consists of

- Humeral head
- Greater Tuberosity
- Lesser Tuberosity

ANATOMY OF THE SHOULDER







- Bicipital Groove
- Proximal Humerus shaft

Head

It is the proximal end and is slightly less than half a spheroid. It has an articular surface covered by hyaline cartilage. It is directed posteromedially and upwards to the glenoid cavity in the pendant arm. The quasispherical surface of humeral head occupies approximately one third of a sphere.

Greater Tuberosity

It is the most lateral part of proximal end of humerus and lies posteriorly and superiorly on humeral shaft providing attachment to infraspinatus, supraspinatus and teres minor.

It is covered by deltoid producing the shoulder's round contour.

Lesser Tuberosity

It lies on the anterior aspect of humerus and subscapularis is attached to it.

Inter Tubercular Sulcus

Also called bicipital groove. It lies between greater and lesser tuberosities. The biceps tendon lies in the groove and is covered by transverse humeral ligament. Floor of the groove receives ribbon like tendon of lattismus dorsi.

Anatomical Neck

It is a slight constriction, adjoining the articular surface, at the junction of head and tuberosities. The boundaries are variable without a distinct line.

Surgical Neck

It is below the greater and lesser tuberosities.

Glenoid

The Glenoid is a shallow, convex structure shaped like an inverted "comma", approximately one third to one fourth of the surface area of the humeral head. It articulates with the humeral head and provides attachment at its rim for the glenoid labrum and capsule.

Glenohumeral Joint

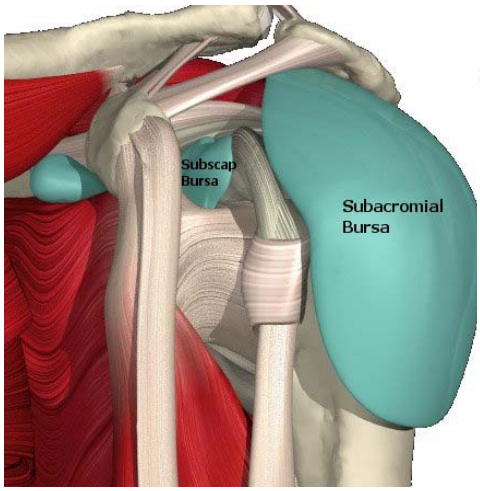
The shoulder joint is a multi-axial spheroidal joint with the greatest range of motion than any other joint in the body. Skeletally the joint is weak and depends for support on surrounding structures which stabilise the joint.

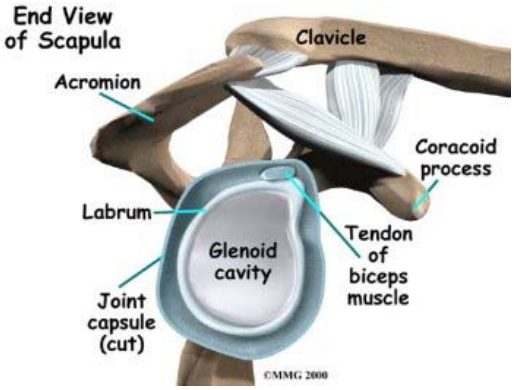
The static stabilisers of the shoulder joint are

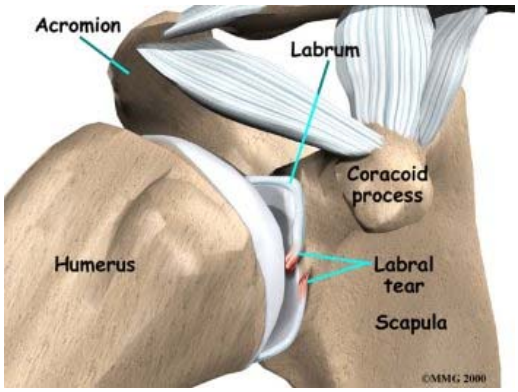
a. Fibrous capsule
b. Glenohumeral ligament
c. Coracohumeral ligament
d. Transverse humeral ligament

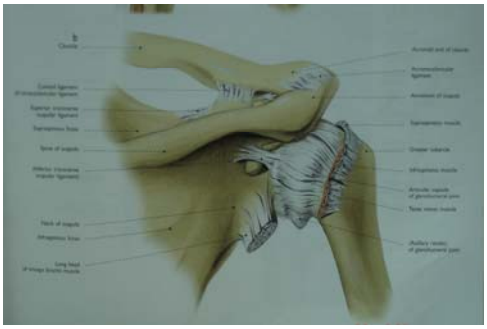
e. Glenoid labrum

ANATOMY OF THE SHOULDER









The dynamic stabilizers are the muscles of rotator cuff, deltoid, trapezius, serratus anterior, Lattismus dorsi, rhomboids & levator scapulae.

The 3 main factors that maintain the dynamic stability of fully developed shoulder joint[29].

1) Normal retrotilt of glenoid articular surface in relation to the axis of the scapula.
2) The optimum retrotorsion of the humeral head in relation to the shaft.
3) Balanced power of the horizontal steerers.

Rotator Cuff

The group of tendons that blend with capsule to insert on the tuberosity is called the rotator cuff. It consists of Supraspinatus, infraspinatus, teres minor, and Subscapularis[30].

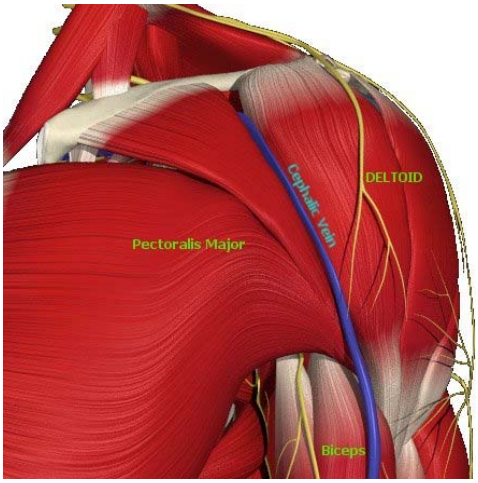
The supraspinatus inserts on the greater tuberosity at the superior facet and superior half of the middle facet.

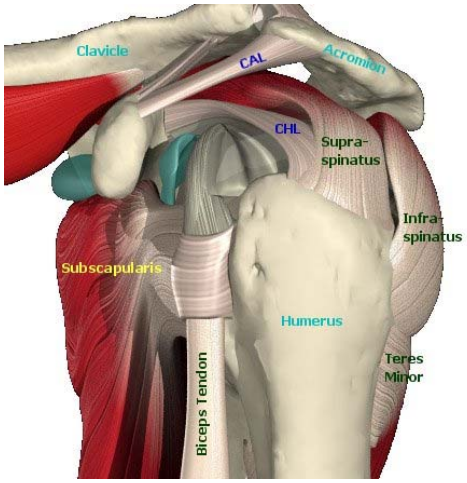
The infraspinatus and teres minor tendons insert farther posteriorly and inferiorly on the greater tuberosity.

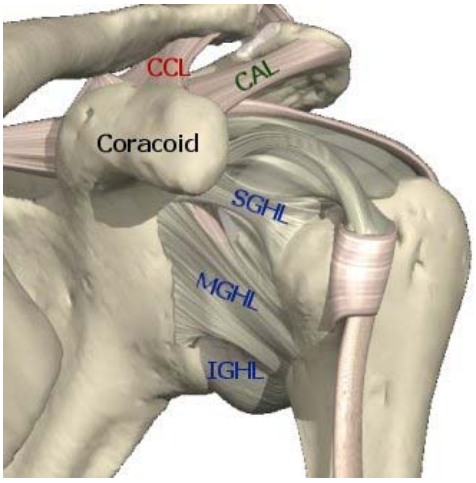
The subscapularis is anterior to the supraspinatus and inserts into the lesser tuberosity.

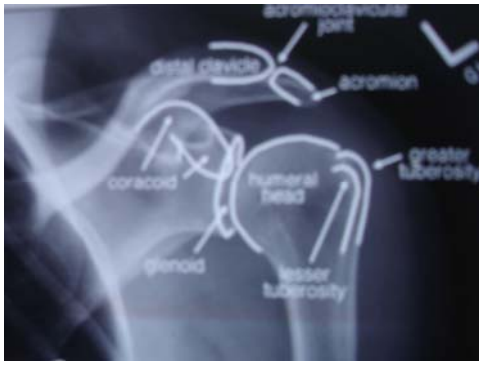
The four muscles act to stabilise the head, which provide a fulcrum for abduction.

ANATOMY OF THE SHOULDER









Surgical Anatomy

Since the rotator cuff muscles are attached to the tuberosities, it is important to understand the direction of pull of their fibers, because this facilitates an understanding of displacement of tuberosity fragments.

In fractures of greater tuberosity, the fragment will be pulled superiorly and posteriorly because of supraspinatus, infraspinatus and teres minor insertion. Reduction by slight abduction helps to reduce the fragment and a tension band fixation neutralises initial displacement forces.

On the other hand in fractures of lesser tuberosity, the fragment will be pulled anteriorly and medially by subscapularis muscle. Horizontal fixation best neutralises these fractures.

The long head of biceps is a significant structure to consider in closed reductions, because it can act as a tether and block reduction. Also during operative procedures, it is a crucial landmark from which rotator interval is identified, so that bone fragments are properly identified and rotator muscles preserved. Also adequate tension in long head of biceps is used to assess alignment in prosthetic replacement.

The deltoid inserting into the deltoid tuberosity can cause displacement of fracture of proximal humeral shaft at the surgical neck.

The pectoralis major inserting into the lip of bicipital groove can displace proximal humeral fracture medially, as usually seen in surgical neck fractures.

The brachial plexus and axillary artery are just medial to coracoid process and care should be taken to prevent injury when osteotomising coracoid for better exposure. It is wise to remember that the lateral side is the best side and the medial side is suicide when osteotomising coracoid.

Axillary nerve leaves the posterior wall of axilla by penetrating the quadrangular space. Then it winds around humerus and enters deltoid muscle posteriorly about 7 cm from tip of acromion. Because of this, care should be taken during dissection of deltoid.

Blood Supply

The major blood supply to the humeral head is from anterior circumflex humeral artery, a branch of third division of axillary artery.

Laing [31,32] was the first to describe the arcuate artery, which is a continuation of ascending branch of anterior circumflex artery and which supplies blood to a large portion of humeral head. It enters the bone in the area of intertubercular sulcus.

Contribution also comes from the branches of posterior circumflex humeral artery through vessel entering the posteromedial aspect of the proximal humerus, metaphyseal vessels and vessels of

the greater and lesser tuberosities[33] and small vessels entering through the rotator cuff insertion.

When anterior circumflex artery is injured close to its entrance to humeral head, it is likely that the blood supply to the head will be compromised resulting in avascular necrosis of head of humerus[34].

Nerve Supply

The shoulder joint is richly supplied by branches from the axillary, musculocutaneous and suprascapular nerves following the Hiltons law [27].

Biomechanics

BIOMECHANICS

The glenohumeral joint has the greatest range of motion than any other joint in the body and also may be the least stable [35].

It is a load bearing joint with significant forces acting across glenohumeral articulation. When the arm is held in 90° of abduction the joint reaction force equals 90% of body weight [2,35].

The shoulder joint is not located in the sagittal or coronal plane of the body. Its axis of motion begins on the curved chest wall, 35° to 45° away from the sagittal plane of the body.

The humeral head is retroverted 30° to 40° to articulate with the scapula and the average adult humeral head has a radius of curvature of 44mm^2. Only 25% to 30% of humeral head articulates with the glenoid at any particular time. The presence of glenoid labrum increases the area of contact.

The intact humeral head is the fulcrum through which the rotator cuff and the long head of biceps act. The resulting force coupled with the action of deltoid provides elevation of the arm while fixing the head within the glenoid cavity. Rotation and elevation are lost if the head fulcrum is destroyed by fracture, dislocation, avascular necrosis or surgical resection.

Avulsion of greater tuberosity is pathognomic of concomitant rotator cuff tear[2]. Tearing of the rotator cuff with a displaced greater tuberosity avulsion destabilized the shoulder and allows superior subluxation to occur with attempted elevation. There is also loss of lever arm and loss of active power. There is also subacromial impingement with loss of normal gliding motion of shoulder[36].

Thus pain, poor motion, loss of strength and endurance can result after Proximal Humerus Fracture, if near normal anatomy is not restored.

CLASSIFICATION

A system for the classification of Fractures occupy a central role in the practice of Orthopeadic surgery. It must be comprehensive enough to encompass all factors, yet specific enough to allow accurate diagnosis and proper management. Also it must be flexible enough to accommodate variation and allow logical deductions for treatment. It should also be both reliable and reproducible.

Kocher's Classification

Devised in 1896, this is based on different anatomic levels for fracture namely,

a. Anatomic neck.
b. Epiphyseal region.
c. Surgical neck.

Limitation

- Does not allow for multiple fractures at different sites
- Does not differentiate between displaced and undisplaced fractures

Watson-Jones Classification

Watson-Jones based his classification on mechanism of injury and divided into three types namely,

a. Abduction type

b. Adduction type

c. Contusion Crack fractures

Limitations

Depending on whether X-rays are taken in internal rotation or external rotation fracture can become either an abduction or adduction fracture and hence not very reliable.

Codman

In 1934 Codman made a significant contribution to the understanding of proximal humeral fractures by proposing that proximal humerus fractures can be separated into four distinct fragments occurring roughly along the anatomic lines of epiphyseal union into,

a. Anatomic head
b. Greater tuberosity
c. Lesser tuberosity
d. Shaft

This formed the basis of future NEER'S classification.

Limitations

It does not describe about biomechanical forces causing displacement or plan for treatment.

Neer's Four Part Classification

In 1970 Neer, Charles of New York proposed the first truly comprehensive system that considered the anatomy & biomechanical forces and related it to diagnosis and treatment. It is based on Codman's four parts. When any of the four major fragments is displaced >1cm or angulated more than 45° then the fracture is considered displaced. It is classified as

a. Undisplaced fracture
b. 2 part fracture
c. 3 part fracture
d. 4 part fracture

Neer's Fracture Dislocation

A fracture dislocation exists, when the head is displaced outside the joint space, not merely rotated and there is in addition a fracture.

It is classified according to the direction of dislocation as

a. Anterior Dislocation
b. Posterior Dislocation

As based on number of fracture fragments as

a. 2 part Fracture Dislocation
b. 3 part Fracture Dislocation
c. 4 part Fracture Dislocation

Or as special fractures as

a. Head splitting fractures
b. Impression Fracture
c. Valgus impacted fracture

AO Classification

Jakob & Colleagues and AO-ASIF group have applied AO System to Proximal Humeral fractures. The system is divided into 3 types according to increasing severity of injury.

Type A

Extra-capsular

Involves two of the 4 fragments

No vascular isolation of articular segment

No avascular necrosis

Least severe.

Type B

Partial intracapsular

Involves three of four fragments

Low risk of avascular necrosis

Partial vascular isolation of head

More severe

Type C

Intracapsular

Involves all four fragments

Total vascular isolation of articular segment

High risk of avascular necrosis

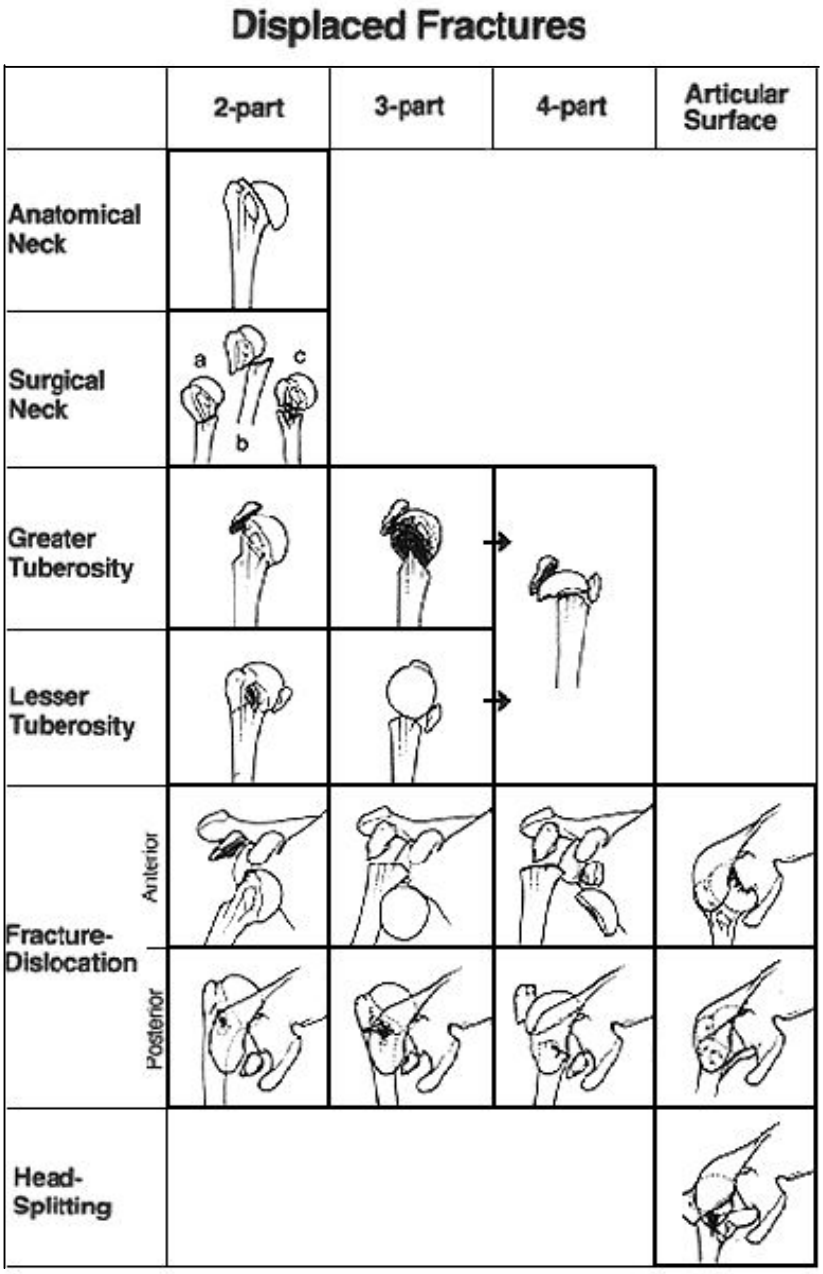
More severe

In addition each alphabetical injury is subgrouped numerically with higher numbers reflecting greater severity.

Of all, the Neer's classification has stood the test of time and still the most commonly followed the world over.It has important implication for both treatment options and outcomes [28,37,38,39].

We also have followed the Neer's classification in our study.

NEER'S CLASSIFICATION



Mechanism of Injury

MECHANISM OF INJURY

The most common mechanism of injury is fall on a outstretched hand from standing height or less [13,40]. In elderly, trauma is only trivial, because bones are osteoporotic.These patients may have associated distal radial fractures.

In younger patients, high energy transfer like RTA is frequently involved resulting in serious injuries with significant soft tissue disruption and multiple trauma.

Another mechanism of injury described by Codman, is excessive rotation of the arm especially in the abducted position when a fracture occurs. Moreover the humerus locks against the acromion producing a pivotal position, facilitating a fracture.

Proximal Humerus Fractures may also result from a direct blow to the side of the shoulder. But the indirect mechanism is usually associated with greater degree of Fracture displacement than the direct mechanism[41].

An often ignored etiology for fracture dislocation of Proximal Humerus is electric shock or convulsive episode. They may have bilateral fracture dislocation.

Clinico-Radiological Evaluation

CLINICO-RADIOLOGICAL EVALUATION

History

A detailed history should include patient's health, handedness, occupation and details of injury. A good understanding of patients general health (i.e. whether he or she has osteoporosis or metabolic disorder or seizures) is of critical importance as it will predict the outcome of surgical fixation.

Clinical Presentation

Most fractures of the Proximal Humerus present acutely and therefore the most common clinical features are pain, swelling and tenderness about the shoulder, especially in the area of greater tuberosity.

Ecchymosis generally becomes visible within 24-48 hrs and may spread to chest wall, flank and distally down the extremity.

Crepitus may be present with motion of the fracture fragments, if they are in contact.

A detailed neurovascular evaluation is essential in all fractures of proximal humerus. The brachial plexus and axillary artery are especially at risk during coracoid osteotomy as they lie medial to coracoid.

The most common nerve that is injured with fractures about the shoulder is Axillary nerve and hence sensation over deltoid insertion must be checked for. Testing for motor function is by asking the patient to attempt shoulder abduction against the examiner's hand while the deltoid muscle belly is palpated for contractions.

Imaging

Precise radiographs are critical in estabilising an accurate diagnosis in shoulder trauma. All too often injuries are missed with radiographs obtained in the plane of body rather than in the plane of scapula. To overcome this limitation, 3 right angled trauma series was introduced. In addition CT scan, 3D CT Reconstruction, Arthrography, and MRI all allow the shoulder injuries to be more clearly defined.

Trauma Series

The 3 view Right angled Trauma Series was popularised by Neer. Trauma series remains the best initial method of diagnosing fractures of Proximal Humerus. It allows evaluation of fracture in 3 separate perpendicular planes, so that accurate assessment of the fracture displacement can be achieved. It consists of

a. AP VIEW IN THE PLANE OF SCAPULA

For scapular plane AP View scapular plane, the posterior aspect of the affected shoulder is placed against X ray plate and the opposite shoulder is rotated out approximately 40°. This allows visualisation of Glenohumeral joint space without any bony superimposition.

b) LATERAL VIEW IN THE PLANE OF SCAPULA

The lateral view in scapular plane is accomplished by placing the anterior aspect of the affected shoulder against X ray plate and rotating the other shoulder out approximately 40°. The X ray tube is then placed posteriorly along the scapular spine. Here scapula appears 'Y' shaped with the glenoid in the centre and the 2 upperlimbs of the 'Y' formed by acromion and coracoid with vertical limb formed by scapular body. This provides a true lateral view of the shoulder.

Tuberosity displacements and direction of dislocation can be appreciated with this view clearly.

c) AXILLARY VIEW

This allows for evaluation of the shoulder in the axial plane and is essential for evaluating the degree of tuberosity displacement, the glenoid articular surface and relationship of humeral head to the glenoid.

Here the arm is held in mild abduction of 30° and the X ray plate is placed above the patient's shoulder. The X ray beam goes inferior to superior.

Another method is VELPEAU AXILLARY VIEW[42] where the arm is not removed from sling. The patient is seated and tilted obliquely backward 45°. The plate is placed on the table and X ray beam is shot from above.

These views can be taken without removing the sling from patient's arm. They can be done in either sitting, standing or prone position with minimal discomfort to the patient.

Special Views

Stripp axillary lateral[43] and the Trauma axillary lateral[44] view are described as special views.

Anterior rim fractures or ectopic calcification in many anteroinferior glenoid labral detachments with instability can be delineated with West Point Axillary View or alternatively, the Cuiollo Supine Axillary View with arm in external rotation.

The Bloom Obata Apical Oblique View[45] is specifically for defining whether there is a posterior dislocation or fracture dislocation.

Screening Views

There are 5 standard Radiographic projections[15] which are useful in screening patients with shoulder complaints, 3 views are AP views

1) Internal Rotation
2) External rotation
3) 100 degree Abduction.

The other 2 views are the Axillary and Bicipital Groove views. Single-contrast Arthrography is valuable in diagnosing full-thickness Rotator cuff tears, adhesive capsulitis, and lesions of the biceps. It also is useful in determining deep surface incomplete cuff tears and occasionally, anterior instability.

Tomograms

Tomograms can be useful in evaluating Proximal Humerus fracture for Nonunion or articular surface incongruity but is largely replaced by CT scan.

CT Scan

CT scan is now the investigation of choice for evaluating Proximal Humerus fracture. It helps to find

a) Displacement of tuberosity fragments
b) Amount of articular involvement with head splitting fractures

c) Impression fracture

d) Chronic fracture dislocation

e) Associated glenoid rim fracture.

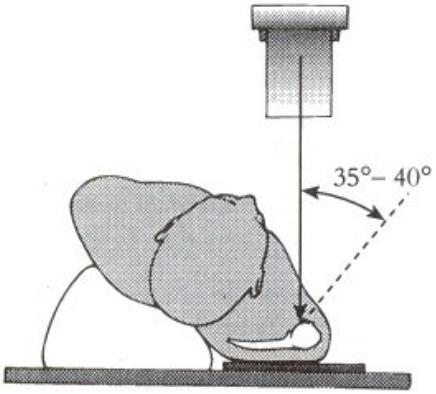
Reconstruction CT

Though not available in all centres, it is extremely valuable to get a 3D Reconstruction model of the fracture, which helps in planning treatment, especially in complex fracture patterns.

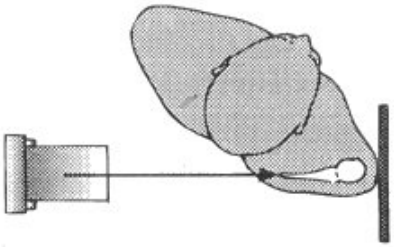
MRI

MRI is useful in showing relation of tuberosity fragments to rotator cuff tendons. It also helps in assessing co-existent rotator cuff injuries.

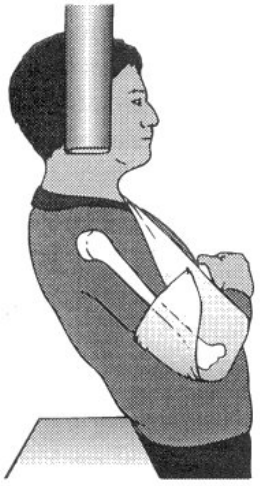
TRAUMA SERIES – RADIOGRAPH POSITIONS



ANTEROPOSTERIOR VIEW IN THE PLANE OF SCAPULA



LATERAL VIEW IN THE PLANE OF SCAPULA



VELPEAU MODIFIED AXILLARY VIEW

METHODS OF TREATMENT

The ultimate goal in the treatment of all fractures is return to usual activities as soon as and to as nearly as normal an extent as possible. Many methods of treatment of Proximal Humerus Fractures have been proposed through the years creating a great deal of controversy and at times confusion. Sound judgement is required to determine the appropriate treatment for each fracture.

The various methods that are available are:

a. Closed Reduction
b. Initial Immobilization and early motion
c. Percutaneous pinning and external fixation
d. Plaster splint and cast
e. Skeletal traction
f. Open reduction and internal fixation
g. Prosthetic replacement

a. Closed Reduction

For years Closed Reduction has been a popular method of treatment for many types of Proximal Humerus Fractures. However, it is important to differentiate between those fractures, which are suitable and those which are not.

Repeated and forcible attempts at closed reduction may complicate a fracture by causing further displacement, fragmentation or neurovascular injury.

Various types of reduction manouveres have been used with mixed results.

Watson and Jones described a classic technique of hyperabduction and traction to achieve a closed reduction.

Displaced lesser tuberosity fractures can be treated by closed reduction if it does not block internal rotation[46].

Three and four part fractures are unstable and difficult to treat by closed reduction. Recent literature has reported poor results with closed reduction, with high incidence of pain, malunion and avascular necrosis.

b. Initial Immobilisation and Early Motion

Initial immobilisation and early motion has been described with varying degree of success for minimally displaced fractures. The shoulder has a large capsule, allowing a wide range of motion that can compensate for even moderate amounts of displacement. The arm is supported by a sling at the side as in Velpeau position. Gentle range of motion exercises are started by 7 to 10 days, when pain has reduced and patient is less apprehensive.

c. Plaster Splints & Casts

Older literature suggested that reduction in an abducted and flexed position was essential for proper alignment and advocated shoulder spica casts and braces to maintain reduction, which were extremely cumbersome and uncomfortable for the patient.

The use of hanging arm cast for fracture of Proximal Fracture should be avoided, because of the tendency of distraction at the fracture site leading to non-union or mal-union.

d. Percutaneous Pins & External Fixation

Percutaneous pinning may be used after closed reduction if reduction is unstable. Jakob & co-workers have outlined the technique and reported satisfactory results in 35 of 40 cases.

This method of treatment is technically demanding but it offers advantage of less disruption of soft tissues and minimal fixation thus reducing the prevalence of avascular necrosis.

Percutaneous pin stabilization is a reasonable option for unstable but reducible surgical neck fractures.

e. Skeletal Traction

The use of traction is not commonly indicated but may be helpful in the management of comminuted fractures.

The shoulder is flexed to 90° and elbow is also flexed to 90°. A threaded 'K' Wire or Steinmann pin is inserted in the ulna, and the forearm and wrist suspended in a sling. The goal is to try to hold the shaft fragments in a neutral position. When there is sufficient callus formation, the traction can be discontinued and the patients arm placed in a sling or spica cast.

f. Open Reduction & Internal Fixation

Closed reduction and external fixation has been unable to correct deformity and maintain reduction sufficiently and hence open reduction and internal fixation has gained popularity[47]. Non-operative trearment of 3-part and 4-part complex fractures often results in malunion and stiffness of the shoulder. In younger or active elderly patients, operative treatment is considered or the joint surface may compromise long term shoulder function substantially[48]. The goal of internal fixation should be anatomical reduction and stable fixation allowing for early range of motion of the shoulder. The internal fixation of complex fractures of the Proximal Humerus restored good shoulder function. The current trend is towards limited dissection of the soft tissue about the fracture fragments & the use of minimal amount of hardware required for stable fixation.

Indications for ORIF

a. Displaced two part anatomic neck fractures in children and young adults.
b. Displaced two part surgical neck fractures with soft tissue interposition preventing closed reduction or if reduction is not stable.
c. Greater tuberosity fractures displaced more than 5 mm
d. Displaced isolated lesser tuberosity fracture especially if fragment is large and blocks medial rotation.
e. All displaced three Part fractures of Proximal Humerus.
f. Displaced four part fractures of Proximal Humerus.
g. In 20-40% of head impression fracture

The choice of surgical approach is dictated by the fracture pattern and includes an extended deltopectoral approach and superior deltoid-splitting approach[49].

In general, 3-part Fractures and 4-part Fracture in younger, active patients are treated with Open Reduction and Internal Fixation and 4-part Fracture in elderly, osteoporotic bone Hemiarthroplasty is done[50]. Recently for 3 part & 4 part osteoporotic fractures, fixed angle stable locking plate used with increasing results.

Implant Selection

Two part anatomic neck fractures:

Two part anatomical neck fractures account for 0.8% of upper humeral fractures.

Fortunately anatomic neck fractures are rare. The prognosis for survival of head is poor, because it has been completely, deprived of its blood supply.

However several authors[37,51,52,53] recommend an attempt at open reduction & internal fixation with screws or pins if the patient is young and prosthetic replacement in older individuals.

Two part surgical neck fractures:

The surgical neck fractures are the most common type of the Proximal Humerus Fractures[3,5,6]. It occurs in all age groups. Displaced fractures can disrupt the function of the upper extremity. Displaced surgical neck fractures can be stabilized by variety of techniques, commonly used are percutanous pin fixation, antegrade and retrograde insertion of intramedullay nails, combination of Ender's nail and suture techniques, plate and screw fixation and External fixation[4,54].

Two part greater tuberosity fracture:

Represents 3% of proximal humeral fractures. 15-30% anterior dislocations are associated with greater tuberosity fractures. Greater

tuberosity fractures displaced more than 5 mm require open reduction and internal fixation, because the posterior and superior displacement of the fragment will cause impingement beneath the acromion.

Screws, tension band wiring, suture materials, plates and screws, percutaneous pinning, have all been proposed. The rent in the rotator cuff that occurs with displaced greater tuberosity fracture must be repaired. Timing and proper treatment of these injuries is crucial as malunion and rotator cuff dysfunction may lead to pain, loss of motion and subsequent disability.

Two part lesser tuberosity fracture:

Displaced isolated lesser tuberosity fractures require internal fixation with non-absorable sutures or wires or screw if the fragment is large and blocks medial rotation.

Some authors have described a method of removal of bone fragment and suturing of subscapularis tendon to the cortical edge of fracture site.

Avulsion fracture of the upper part of the Lesser Tuberosity appears to have been caused by hyperextension and hyperexternal rotation of the shoulder.

Three –part fracture:

Three and four part fractures represent 13% to 16% of Proximal Humeral Fractures. Open reduction & internal fixation is the treatment of choice for displaced three part fracture of Proximal Humerus. It is important to avoid extensive exposure and soft tissue dissection of fragments which may compromise blood supply. Intramedullary nails is usually not adequate to neutralise deforming forces. The AO buttress plate gives good results but may require extensive soft tissue stripping.

Hawkins& Co-workers[56] reported good results in 14 of 15 patients treated with "figure of 8" wire for three part fractures. In osteoporotic bones, wire or non-absorbable suture can be passed through rotator cuff as well as bone of tuberosity and then attached to shaft. This gives sufficient stability to begin early motion. TBW is an accepted method of treatment for 3 part fractures.

Locking plates improve torsional resistance in the stabilization of 3-part Proximal Humerus Fractures. It has better torsional fatigue resistance and stiffness than blade plate[3].

Four part fracture:

It is about 5% of all Proximal Humerus Fractures[4], and 19% incidence of humeral head necrosis occurs in these fractures[57].

Open reduction & internal fixation of four part fractures with pins, rods, plates and screws can be done but the results usually are not promising. These fractures usually occur in elderly people in whom osteoporosis and poor bone quality preclude any stable internal fixation. Prosthetic replacement offers a distinct advantage in these fractures permitting early motion and return to work. The recent concept of LCP in these patients is gaining momentum.

In general, surgical management of 2-part and 3-part Proximal Humeral Fractures is difficult and requires familarity with more than one method of fixation. Poor bone quality, comminution, and the deformity forces of the rotator cuff on the tuberosities influence the choice of operative approach and fixation techniques. Closed reduction and percutaneous pinning offer the potential advantage of minimal soft-tissue dissection; however, good bone quality and minimal comminution are prerequisites [49].

Prosthetic Replacement:

The use of humeral head prosthesis for Proximal Humeral fracture was first reported in the early 1950. The original Neer's I prosthesis was designed in 1951. In 1953, Neer reported the first use of this prosthesis for complex fracture dislocation of Proximal Humerus. The original prosthesis was revised by Neer in 1973 [Neer II] to a more anatomic surface design.

Aim is to establish proper humeral head version & proper myofascial sleeve tension within the rotator cuff & deltoid musculature[11]. The prosthesis has two head sizes 15 & 22 mm in thickness. The larger size gives better leverage and mechanical advantage for forward elevation but the smaller size may be required for coverage by the rotator cuff. There are three stem sizes 7, 9.5 and 12mm and two stem length 125 and 150mm. Longer stem length are available, if needed to bridge a shaft fracture[21]. Recently modular hemiarthroplasty has been used in treatment of complex fractures of Proximal Humerus. The modular humerus design offers greater flexibility in head sizes, perhaps allowing more precise tensioning of soft tissues. Moreover the ability to disassemble the component allows easier access to the glenoid if revision to a total replacement is contemplated later[59,60,61,62].

A new shoulder prosthesis design for Proximal Humerus Fracture has been developed. The rim of the articular component of this prosthesis has several holes to which the bone-tendon junction of the rotator cuff is fixed, to allow an anatomic reconstruction of the glenohumeral unit.

Indications for prosthetic replacement[63]:

a) Displaced anatomic neck fracture in adults
b) Extensive head impression, splitting or crushing fractures.

c) Three part fractures that are tenous and unstable after attempted open reduction.

d) Unstable four part fracture dislocation

e) In chronic cases of avascular necrosis, malunion or nonunion with joint incongruity.

f) Surgical neck non-union.

g) Greater than 40% head impression fractures and chronic dislocations.

Prosthetic replacement is a good treatment in osteoporotic patients with 4 part fractures, fracture dislocation, split fractures with more than 40% articular surface involvement, anatomic neck fracture, dislocation present for longer than 6 months. Early prosthetic replacement of Proximal Humeral Fractures has better outcome than late reconstructive prosthetic replacement[12].

In osteoporotic bone bulky, stiff implants are inadequate and may cause additional damage. Load sharing, not load bearing compound constructions are the aim. Obtaining elastic buttressing is the key element in achieving the necessary load sharing[9].

The return of function is governed by the security of tuberosity-muscle cuff repair, sufficient protection after operation and long term physiotherapy.

Constrained Replacement

Reserved for the patient who requires arthroplasty and does not have a functional rotator cuff mechanism. If, in addition, the acromion fulcrum and loss of deltoid is present, then there is a greater reason for constrained replacement.

The optimal prosthetic reconstruction of the shoulder is dependent on prosthetic design, soft tissues, postoperative healing and rehabilitation, and the long term biologic response to the implant.

Surgical Approaches

There are many approaches used for treatment of fractures of Proximal Humerus. An approach which allows greatest visualization for performing a repair or fixation with the least disruption of soft tissues should be chosen for better functional recovery[64].

The various approaches are

A. Anterior deltopectoral approach

B. Superior approach without anterior acromioplasty

C. Deltoid splitting approach

D. Posterior approach

Only the approaches that we have used in our study has been dealt below.

Position of the patient

Place the patient supine on the operating table. Wedge a sand bag between the spine and medial border of scapula to push the affected side forward while allowing the arm to fall backward thus opening up the front of the joint. Elevate the head of the table to 30° to 45° to reduce bleeding and to allow blood to drain away from the operative field.

A. Anterior deltopectoral approach

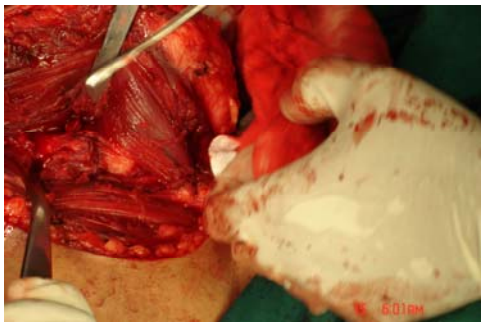
A 15cm long incision is made from above the coracoid and carried distally in the line of deltopectoral groove to the deltoid insertion. The internervous plane lies between deltoid, which is supplied by axillary nerve and pectoralis major which is supplied by medial & lateral pectoral nerves. The cephalic vein is preserved with retraction towards either the deltoid or pectoralis major.

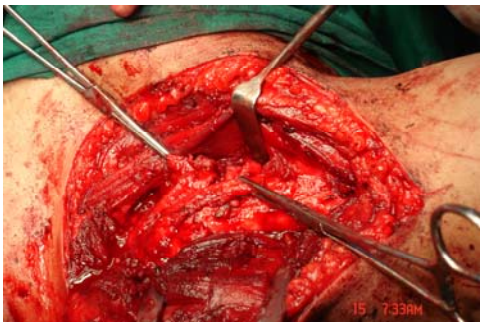
Rarely it may be ligated. The clavipectoral fascia is incised .The muscles attached to the coracoid are retracted medially. With the arm abducted, anterior 1cm of deltoid is released and retracted laterally and retained with Richardson retractor. The long head of biceps, the key to anatomy of upper humerus is found under the insertion of pectoralis major. Palpate it as it proceeds upwards, but do not dissect it free, for fear of avascular necrosis. If lesser tuberosity is not fractured access is gained to the front of the joint by means of a

directed subscapularis and capsular longitudinal arthrotomy. Rarely coracoid osteotomy may be required for better exposure.

SURGICAL APPROACH

SURGICAL APPROACH





B. Deltoid splitting approach

Begin the incision at the anterolateral tip of acromion and carry it distally over the deltoid muscle about 5 cm. Define the tendinous interval 4-5 cm long between anterior and middle thirds of the deltoid, splitting the muscle here provides a fairly avascular approach to the underlying structures. Next, incise the thin wall of subdeltoid bursa and explore the rotator cuff and tuberosities.

Intra operative complications include:

a. Fracture of humeral shaft from forceful manipulation.

b. Displacement of previously undisplaced fracture.

c. Poor holding of sutures, 'K' wires, in tuberosities in osteoporotic bones

d. Damage to deltoid with retraction

e. Damage to axillary artery

f. Damage to brachial plexus

g. Damage to axillary nerve

h. Torrential bleeding

Post-operative care and rehabilitation

Proper postoperative rehabilitation is essential to ensure the achievement and maintenance of satisfactory range of motion, strength and function of the shoulder[56,65,66].

Rehabilitation should be custom tailored to the patient and the fracture type, and is easier, more comfortable and more assured with firm internal fixation. If fracture repair is stable, then therapy can be started early. The most useful rehabilitation protocol is the three-phase system devised by Hughes and Neer[67].

Application of this system is variable and depends on the type of fracture, stability of fracture fixation and ability of patient to comprehend the exercise programme.

Phase I:

Phase I exercises are started early in the postoperative period, if the fracture is treated by closed reduction, then exercises are started between 7th and 10th post-operative day. First exercise is usually pendulum exercise. The second exercise is supine external rotation with a stick. Three weeks after fracture, assisted forward elevation as well as pulley exercises are added. Isometric exercises are started at four weeks.

After stable surgical repair, passive exercises can be started within 24-48 hrs. The physician should start elbow flexion and extension. Then gently assist the patient with pendulum exercises. Supine external rotation and assisted forward elevation are also performed. Assisted pulley exercises can be started after 6 weeks.

Phase II:

This involves early active, resistive and stretching exercises. The first exercise is supine active forward elevation. 3 sets of 10-15 repetitions are done at each session. Stretching for forward elevation on top of door is then done. The extremely important exercise to achieve abduction and external rotation is to place the hands behind the head with arm abducted and externally rotated.

Phase III:

Phase III exercises, resistive strengthening, started at three months. Arm is stretched higher on top of wall by leaning the torso onto the wall. Prone stretching for forward elevation is also useful. Light weight can be used after three months. Weights are started at one pound and increased at one pound increments with the limit being 5 pounds. Strength can be achieved with functional activity.

A well supervised rehabilitation regimen is essential for successful fracture treatment. Even a perfect surgical repair will not achieve good results, without proper rehabilitation efforts[68].

MATERIALS AND METHODS

This prospective study is an analysis of functional outcome of 20 cases of surgically managed displaced Proximal Humeral Fractures, undertaken at Department of Orthopaedics and Traumatology, Government Royapettah Hospital, Royapettah, Chennai. From may 2004 to september 2006. Of the 20 patients, 12(60%) were females and 8(40%) were males. (Table-I). The age of the patients ranged from 16-70 years. The mean age of the patients was 44 years.(Table- II)

TABLE – I

SEX DISTRIBUTION

S. No.	Sex	No. of Patients	Percentage
1.	Females	12	60
2.	Males	8	40

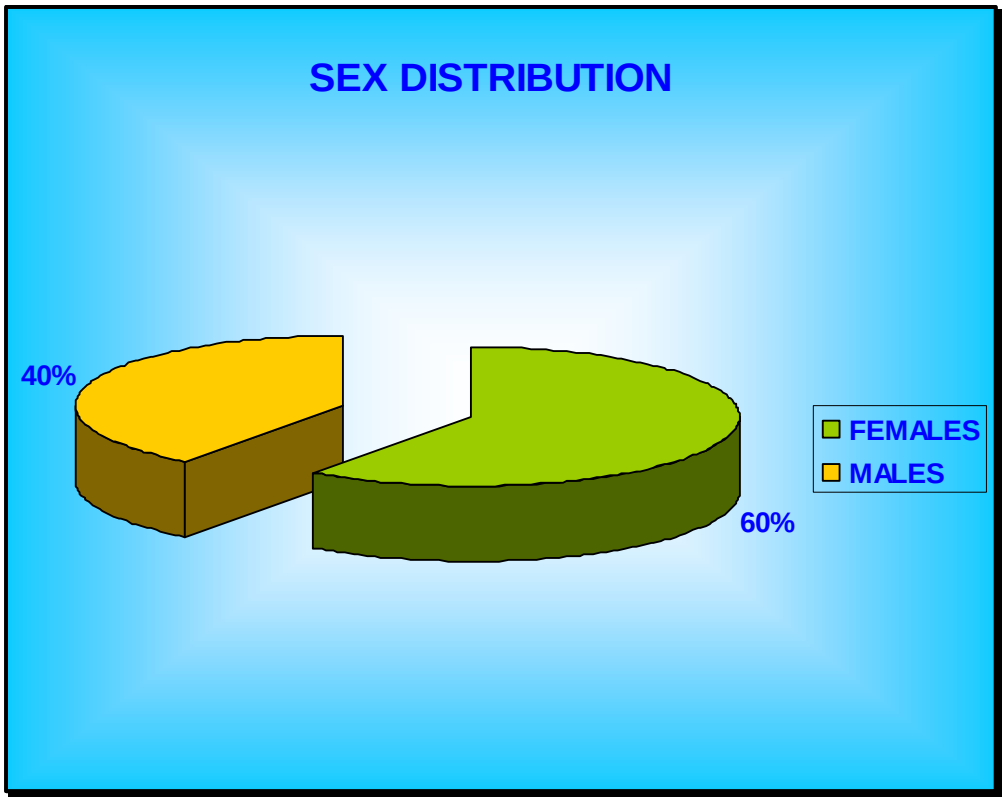

SEX DISTRIBUTION
40%
60%
FEMALES
MALES

TABLE – II

AGE DISTRIBUTION

S. No	Age group	No. of Patients	Percentage	Males	Females
1	0-10	0	0	0	0
2	11-20	1	5	1	0
3	21-30	3	15	2	1
4	31-40	3	15	2	1
5	41-50	4	20	1	3
6	51-60	6	30	1	5
7	>61	3	15	1	2

The mode of injury was fall at ground level in 10(50%) patients, road traffic accident in 6(30%)patients, fall from height in 3(15%) patients, fall due to epilepsy in 1(5%) patients.(Table III.)

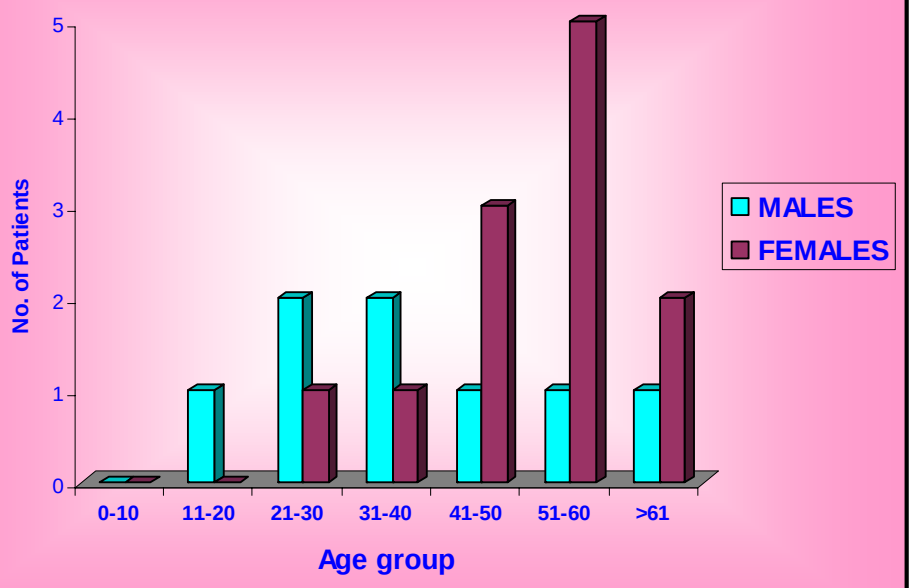
TABLE III

MODE OF INJURY

S. No.	Mode of injury	No. of Patients	Percentage
1	fall at ground level	9	45
2	Rta	7	35
3	Ffh	3	15
4	Epilepsy	1	5

The occupation of the patients is described in the following table. [Table-IV]

AGE DISTRIBUTION



MODE OF INJURY

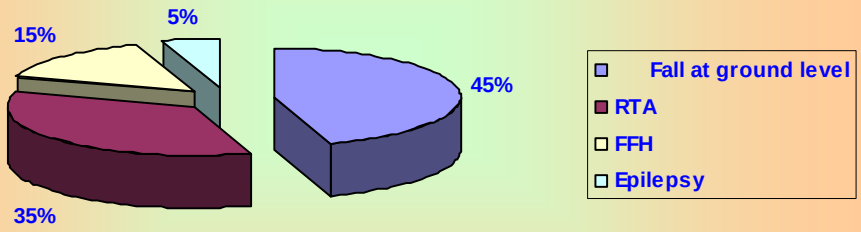


TABLE – IV

OCCUPATION

S. No	Occupation	No. of Patients
1	Labourer	3
2	House wife	6
3	Skilled worker	8
4	Professional	1
5	Student	1
6	Business	1

TABLE – V

S.No	Side	No. of patients
1	Unilateral	20
2	Bilateral	0

TABLE- VI

SIDE

S.No	Side involved	No: of patients
1	Dominant(Right)	16
2	Non-dominant(Left)	4

Seventeen patients presented to us within a week after injury,(Table-VII) and 7 patients had previous treatment either in the form of native splinting, massage or POP cast. (Table -VIII)

TABLE – VII

DURATION

S. No	No of days Since injury	No. of patients
1	0-5 days	17
2	6-10 days	1
3	11-15 days	2

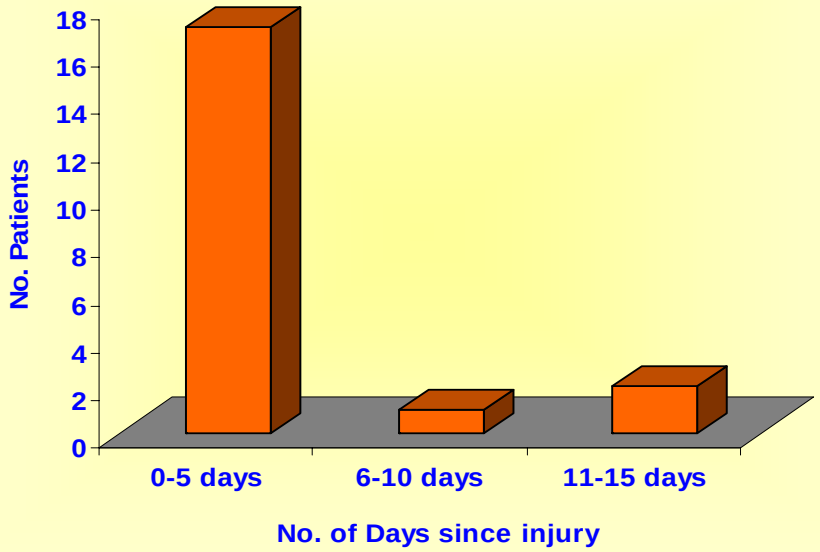
TABLE – VIII

PREVIOUS TREATMENT

S. No	Previous treatment	No. of patients	Percentage
1	Massage	2	10
2	Massage and splinting	0	0
3	Splinting	2	10
4	Attempted reduction with splinting	1	5
5	POP	2	10
6	No native treatment	13	65

A meticulous clinical examination was made in all patients with care to look for any associated injuries. 8 patients had associated ipsilateral skeletal injuries which were concomitantly treated. [Table-X].

DURATION



PREVIOUS TREATMENT

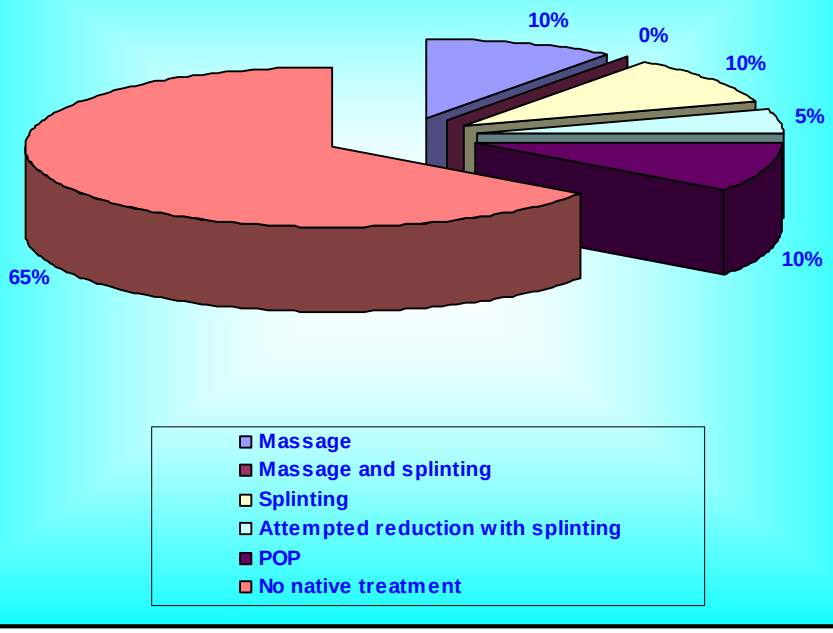


TABLE – IX

S. No	Fracture	No. of patients
1	Closed fracture	20
2	Open fracture	0

TABLE – X

S. No.	Associated injuries	No. of patients
1	Fracture metacarpal	2
2	Fracture scapula	1
3	Fracture distal radius	2
4	Fracture SOH	1
5	Fracture NOF	1
6	Fracture BB Forearm	1

Standard anteroposterior radiographs of the affected shoulder were taken in all patients and most of them were further evaluated with Neer's three view trauma series which involves the AP View in the plane of scapula, lateral view in plane of scapula and axillary lateral view. CT Scan was done in 6 patients with complex fracture dislocations, to delineate the fracture pattern and the direction of dislocation and for 3 patients 3D CT was taken to ascertain the position of the fragments (Table – XI).

TABLE – XI

IMAGING

S. No	Imaging	No. of patients
1	x-rays	20
2	CT Scan	6
4	3D CT	3
3	Bone scan	0

Radiological evaluation of the fractures was done and were classified according to Neer's four part classification system.

Based on Neer's sytem 10 patients (50%) had two part fractures, 5 (25%) patients had 3 part fractures and 5(25%) had four part fractures. (Table-XII) Fracture dislocations were present in 8 patients (Table-XIII).

TABLE – XII

TYPE OF FRACTURE

S. No	Neer's type	No. of patients	Percentage
1	2 part	10	50
2	3 part	5	25
3	4 part	5	25

TABLE – XIII

FRACTURE DISLOCATION

S. No.	Dislocation	No. of patients	Percentage
1	No dislocation	12	60
2	Dislocation	8	40
	2 part	4	50
	3 part	2	25
	4 part	2	25

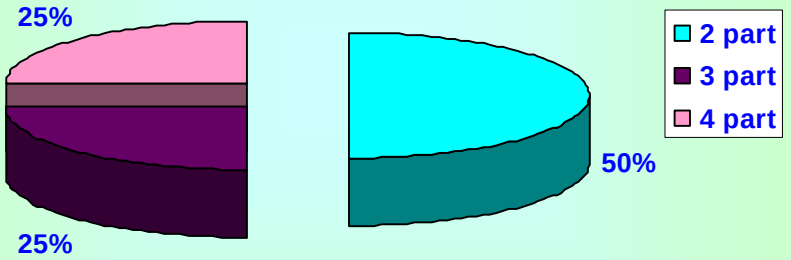
The indications for surgery were displacement more than 1 cm and angulation more than 45°. Patients not satisfying these criteria were treated conservatively and not included in this study.

IMPLANTS

The patients were operated by the standard anterior deltopectoral approach, Deltoid splitting or percutaneous procedure depending upon the type of fracture and bone quality.

Implants were selected according to the geometry of the fracture. (Table XIV)

TYPE OF FRACTURES



FRACTURE DISLOCATION

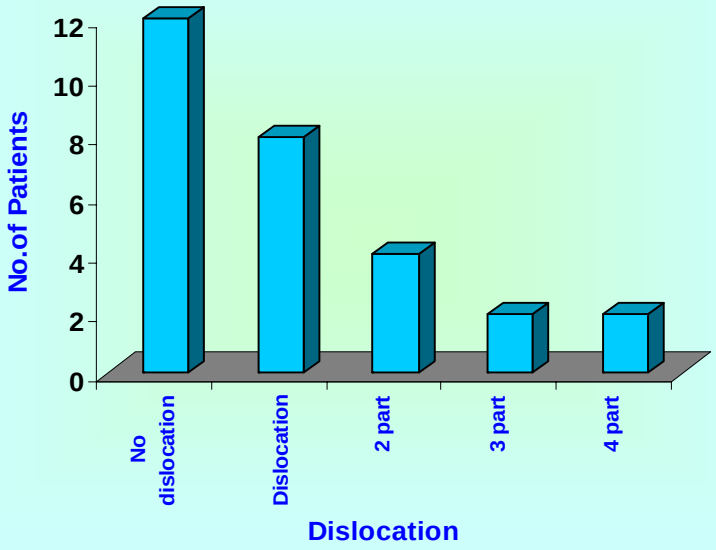


TABLE XIV

IMPLANTS

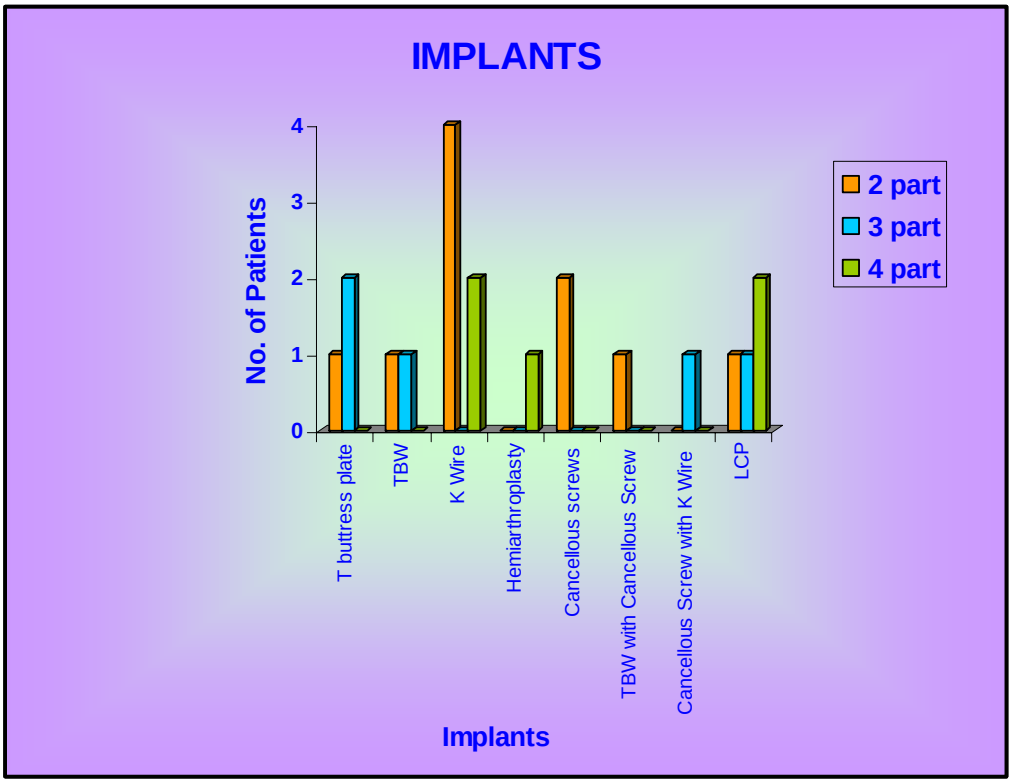
S. No.	Implants	No. of patients	2 part	3 part	4 part
1	T buttress plate	3	1	2	0
2	TBW	2	1	1	0
3	K Wire	6	4	0	2
4	Hemiarthroplasty	1	0	0	1
5	Cancellous screws	2	2	0	0
6	TBW with Cancellous Screw	1	1	0	0
7	Cancellous Screw with K Wire	1	0	1	0
8	LCP	4	1	1	2

Cancellous screw fixation:

For cancellous screw fixation the displaced greater tuberosity fragment was reduced with a bone holding forceps and drill holes made with 3.2mm drill bit and 6.5 mm cancellous screws inserted after tapping the near cortex.

Buttress plating:

For AO 'T' buttress plating the fracture fragments were reduced. 'T' plates were placed on lateral aspect and stabilized with cancellous screws for the tuberosity fragments and cortical screws for the shaft.


IMPLANTS
No. of Patients
0
1
2
3
4
2 part
3 part
4 part
T buttress plate
TBW
K Wire
Hemiarthroplasty
Cancellous screws
TBW with Cancellous Screw
Cancellous Screw with K Wire
LCP
Implants

Tension band wiring:

For Tension band wiring 'K' wires were passed from the greater tuberosity into the shaft. The 'K' wires were cut close to the tuberosity and bent. Drill hole was made in the shaft and 18 G SS wire was passed in the form of 'figure of 8' from the 'K' wires to the drill hole, stabilizing the fracture fragments.

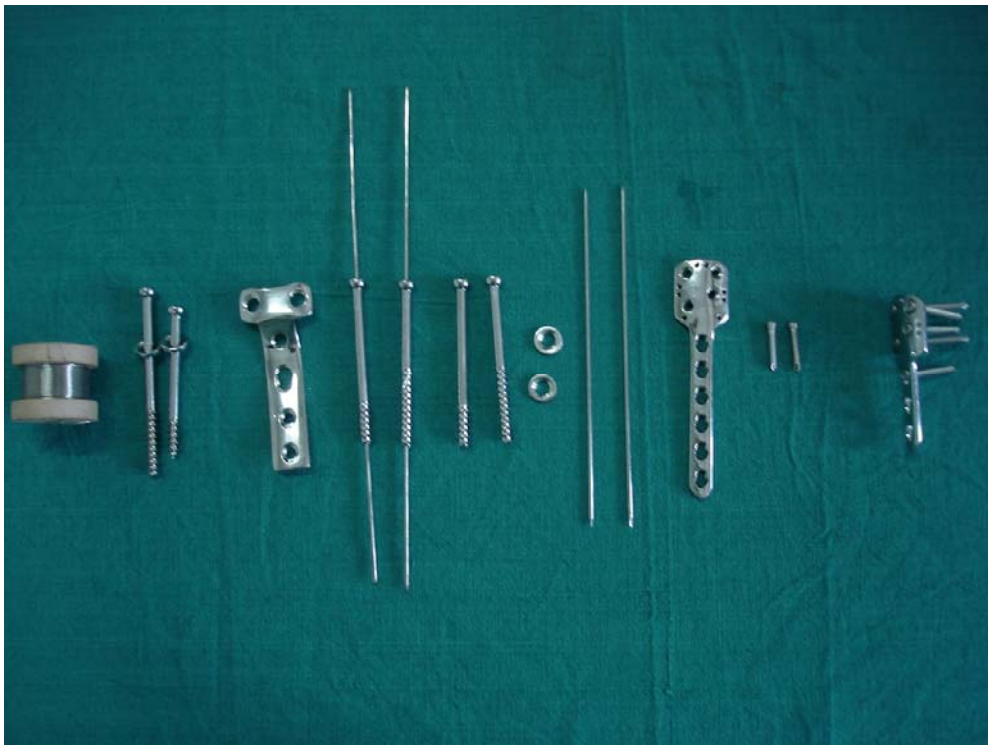
Minimal fixation with 'K' wire:

For minimal fixation with the 'K' wires, the 'K' wires were passed from the shaft to the head of humerus and another K wire from the greater tuberosity to the medial cortex of humeral shaft. For severely displaced 4 part fractures, 'K' wires were inserted through the fractured pieces to the main fragment under C-arm control.

Hemiarthroplasty:

For hemiarthroplasty the standard anterior deltopectoral incision was extended down to expose the shaft. Deltoid origin is preserved and not elevated. Subscapularis was retracted medially with lesser tuberosity to expose the interior of joint. The articular head fragment was removed and the joint cleared of blood clots and bone debris. The intra-articular portion of biceps was identified as it attaches to the supraglenoid tubercle of scapula. If it were not injured,

IMPLANTS



FROM LEFT:

1. SS WIRE
2. CANCELLOUS SCREWS WITH WASHERS
3. ‘T’ BUTTRESS PLATLE
4. CANNULATED SCREWS
5. CANCELLOUS SCREWS
6. WASHERS
7. ‘K’ WIRES
8. LOCKING COMPRESSION PLATE
9. LOCKING SCREWS
10. LOCKING PLATE WITH SCREWS

it was preserved by retracting it laterally. The stem diameter and length required in the proximal 12 -15 cm of the medullary canal were estimated. Once the stem size and neck length were determined, the prosthesis was inserted by hand in 35-40° of retroversion. The amount of retroversion was determined by flexing the elbow to 90° and palpating the epicondyles. Suture was passed through tuberosities or tendon bone junction and through holes in the neck of prosthesis. Anatomic reduction of tuberosities was done beneath the collar or head of prosthesis and sutures tightened. Polymethylmethaacrylate cement was used to secure the prosthesis in bone, if fixation was not adequately stable.

Screw-Tension band Technique:

Placement of a cancellous lag screw from the humeral shaft into the humeral head provides initial stability between the head and shaft, facilitates placement of the tension band wires. It does not violate the subacromial space. A 6.5 mm AO screw and two 18G SS wires were used. One placed into the tuberosities and one under the rotator cuff [5].

Locking Compression Plate:

Proximal Humeral Fractures in older patients with osteoporosis present challenges to conventional plates and screws resulting in

early loosening and failure. To overcome this fixed angle locking plate is being used. It is also used in complex 3 part & 4 part fratures. Fixed angle locking plate provides stable screw fixation construct within the head. Angular stability is provided between the plate and the locking head screws, allowing the implant to act as internal fixator. Load transfer between the fragments occur over the implant. It provides great resistance against bending and torsional forces than conventional plates[9,11]. Additional holes permit fixation of rotator cuff with greater tuberosity. The LCP is placed on the lateral side of humerus, approximately 5 mm below the tip of greater tuberosity. Temporary fixation of plate with 1.8 Kirschner wires is done. The proximal locking screws were inserted into the humerus head before the distal screws were inserted into the humeral metaphysis or diaphysis. The screws alternatively diverge and converge gaining great purchase and superior screw pullout strength. Standard AO cortical screws were used to fix the plate to the shaft. Instead cancellous screws were used in severely osteoporotic bone. In Koukakis et al[78] study mean Constant shoulder score was 76.1%. Only one patient had avascular necrosis. There were no cases of impingement syndrome[6]. Locking plate improve torsional resistance in the stabilisation of the 3 part fractures [7,8].

Fracture-Dislocation

In irreducible fracture dislocations and head splitting fractures the coracoid was predrilled and osteotomised and retracted with the tendon. Arm was externally rotated and blunt instrument passed between subscapularis and capsule and stay sutures applied. It was divided one inch from its insertion and retracted. Capsule was incised longitudinally to open the joint and reduce the articular fragment.

In all patients, the rotator interval between anterior edge of supraspinatus and superior edge of subscapularis was closed with multiple interrupted sutures. The deltoid was reattached to the clavicle and wound irrigated and closed over suction drain.

Post-Op Rehabilitation

In all patients the arm was placed in an arm sling and POP applied if fixation was not stable(Table XV). Prophylactic antibiotics which were started before surgery were continued for 48 and 72 hours postoperatively. In a few, ice packs were used to decrease the swelling. Passive elbow flexion and extension were started by 24-48 hrs. Sutures were removed by 10th post op day.

Phase I exercises consisting of pendulum exercises were encouraged from the first week. Gentle passive forward flexion and internal and external rotation were started by third or fourth week. Phase II exercises consisting of active range of motion exercises and

resistive exercises were started by 4-6 weeks. Phase III exercises consisting of advanced stretching and strengthening exercises were started by 3 months. Light weight lifting were started after 3 months.

TABLE XV

POST-OP IMMOBILISATION

S. No.	Immobilisation	No. of patients
1	Post-op POP	5
2	Arm sling	10
3	Shoulder Immobiliser	3
4	Cuff & Collar	2

All the patients were followed up monthly, for first three months and later, every 3 months. During follow-up, patients were clinically evaluated for pain, function and rotation. Radiological evaluation of fracture union was observed by serial x-rays.

Observations

OBSERVATIONS

- ✓ Majority of injured patients were females (60%).
- ✓ Highest number of patients were in their 5th decade (30%).
- ✓ Free fall at ground level was the most common mode of injury (45%)
- ✓ Post-epileptic fall caused fracture of Proximal Humerus in one patient.
- ✓ There was no case with bilateral fractures.
- ✓ All were right handed persons and the dominant arm was involved in 16(80%). patients.
- ✓ Post menopausal osteoporotic females accounted for 45% of patients.
- ✓ 10(50%) patients reported to hospital on day of injury.
- ✓ 35% of patients had undergone previous native treatment either in form of massage or splinting.
- ✓ 8 patients had associated fractures.
- ✓ All the patients had closed injuries
- ✓ Neer's 2 part fracture is the most common type in 50% patients.
- ✓ Greater Tuberosity fractures were the predominant type in 2 part fracture.
- ✓ 4 part fractures accounted for only 25% of patients
- ✓ Fracture dislocation were present in 8(40%) of patients.

- ✓ Post operative immobilization with POP was used in 5 patients.
- ✓ Patients were taken up for surgery on an average of 7.95 days after injury.
- ✓ 4 patients underwent ORIF with Locking Compression Plate.
- ✓ Among patients with 2 part fractures, 2 were treated with cancellous screws, 3 were treated with 'K' wires, and 1 with TBW.
- ✓ Among patients with 2-part fracture dislocations, one was treated with TBW & Cancellous screws, 1 with 'T' Buttress, 1 with LCP and 1 with 'K' wires.
- ✓ 1 patient with 4 part fracture underwent Hemiarthroplasty
- ✓ Average follow-up period was 12.2 months.
- ✓ 55% patients did not have any pain during follow-up
- ✓ The average range of active elevation in these patients was 127.75°
- ✓ The average range of active external rotation 47°.
- ✓ The average range of abduction 121.25°
- ✓ 18(90%) of patients had normal muscle strength in shoulder.
- ✓ Patients with 2 part fracture had better functional outcome than 3 and 4 part fracture.

Complications

COMPLICATIONS

Early Complications

Early complications were encountered in 4 (20%) patients. [Table-XVI].

1 patients with 3 part fracture treated with 'T'buttress plate developed skin necrosis which resolved with IV antibiotics.

1 patient with Diabetes Mellitus had wound gaping requiring secondary suturing after glycaemic control.

1 patient had deltoid atony after surgery which improved with sling and strengthening exercises.

TABLE XVI

EARLY COMPLICATIONS

S. No	Complications	No. of Patients
1	Skin necrosis	1
2	Wound gaping	1
3	Axillary nerve damage	1
4	Deltoid atony	1

Late Complications

Late complications were encountered in 5(25%) of patients. [Table-XVII].

1 patient with 3 part fracture had malunion of greater tuberosity, restricting abduction above 90°.

1 patient had heterotopic ossification probably because the patient had undergone native treatment with massage and attempted reduction and surgery was performed 18 days after injury.

The patient who had deltoid atony initially after surgery had mild inferior instability which was not incapacitating for the patient.

2 patients had joint stiffness. Both of them later required manipulation under general anaesthesia.

TABLE–XVII

LATE COMPLICATIONS

S. No	Late complications	No. of Patients
1	Non-union	0
2	Malunion	1
3	Joint stiffness	2
4	Heterotopic ossification	1
5	Instability	1
6	Infection	0

Results

RESULTS

The patients were followed up at regular intervals (ie) every month during the first 3 months and every 3 months thereafter. The minimum follow-up period was 6 months and maximum follow-up period was 24 months. The mean follow-up period in this study was 12.2 months.

The results were evaluated during follow-up by taking into consideration the following factors:

1) Pain
2) Range of motion
3) Strength
4) Stability
5) Function
6) Roentgenographic documentation of fracture healing
7) Anatomic restoration

Constant Score:

Constant and Murley's score [69,70,71,72,73] was used to assess the functional outcome of these patients.

The results were graded by using Neer 100 units Rating System.

This Rating system consists of

35 units for PAIN

30 units for FUNCTION

25 units for RANGE OF MOTION

10 units for ANATOMY

PAIN

Post op pain was recorded on a scale of 0-5points, where points were given according to the following criteria

TABLE - XVIII

Pain scale	Points
No pain	5
Mild pain	4
Pain after unusual activity	3
Pain at rest	2
Marked pain	1
Complete disability	0

11(55%) patients said that may had no pain and 5(25%) patients had only mild pain, 2(10%) patients had pain after unusual activity and pain at rest in 2(10%) patients. No patient had disabling pain.[Table-XIX]

TABLE–XIX

EVALUATION OF PAIN

Sl. No	pain	No. of Patients
1	No Pain	11
2	Mild pain	5
3	Pain with unusual activity	2
4	Pain at rest	2
5	Marked pain	0

6	Complete disability	0

FUNCTION

Function was evaluated with ability to perform day to day activities.

Points were given according to the following scale

4 – normal 3 – mild compromise

2 – with difficulty 1 – with aid

0 – unable NA – not available

Functional results were graded by following criteria:

Good functional result 3.5 – 4.0 points

Fair 2.5 – 3.4 points

Poor < 2.5 points

10 (50%) of the 20 patients had good functional result, 8 (40%) had fair functional results and 2(10%) had poor functional result. [Table-XX]

TABLE–XX

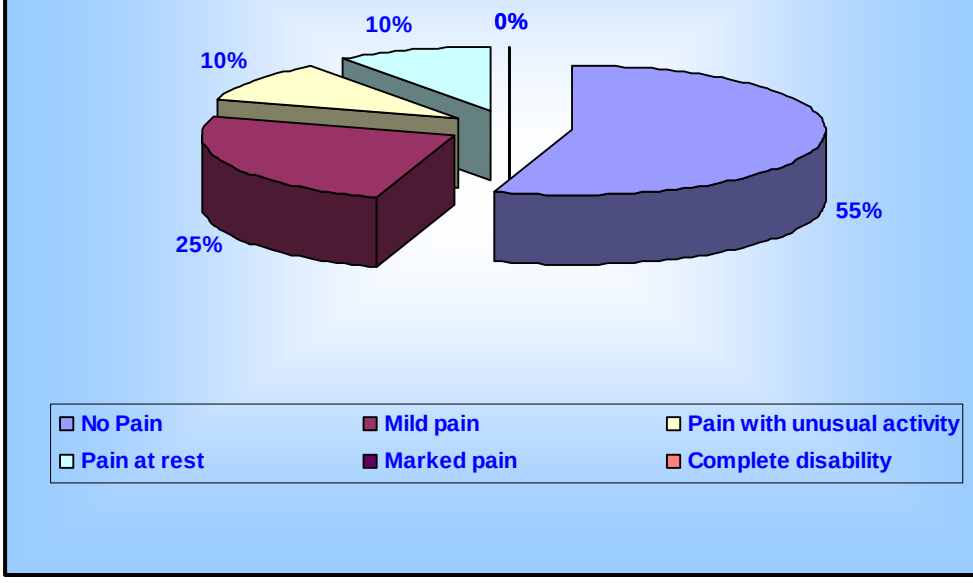
FUNCTIONAL OUTCOME

S. No	Functional outcome	No: of patients
1	Good	10
2	Fair	8
3	Poor	2

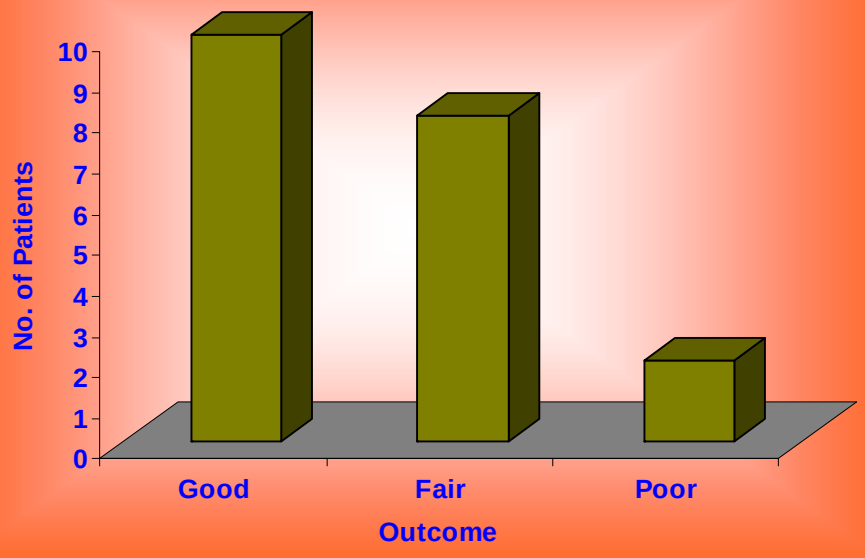
Muscle Strength

Muscle strength was evaluated for the muscles around the shoulder and points allotted accorded to strength as follows:

EVALUATION OF PAIN



FUNCTIONAL OUTCOME



Normal - 5

Against slight resistance -4

Against gravity - 3

With elimination of gravity - 2

Flicker – 1

Paralysis - 0

18 90%) of patients had normal muscle strength in all the muscle groups evaluated and 1 patient had good muscle strength and 1 patient had fair muscle strength. [Table-XXI]

TABLE–XXI

MUSCLE STRENGTH

S. No	Muscle Strength	No: of patients
1	Normal	18
2	Against slight resistance	1
3	Against gravity	1
4	With elimination of gravity	0
5	Flicker	0
6	Paralysis	0

Range of Motion

ROM was evaluated during each follow-up and the improvement and progress recorded. The following table shows average ROM observed. Active forward elevation was defined as the angle between the humerus and the upper part of the thorax in the sagittal plane. External rotation was measured with the arm at patients side. Internal rotation was measured was recorded as the posterior body segment that could be reached by the thumb with the elbow in a flexed position. [Table-XXII]

TABLE–XXII

ROM

S.No	Motion	Range in deg.	Average
1	Elevation	90-170	127.75
2	Abduction	70-160	121.25
3	ER	35-60	47
4	IR	T3-L4	T11
5	Extension	30-55	41
6	Flexion	80-120	92.75

Overall Results

The results were rated according to the following criteria:

Maximum no: of points – 100 Excellent – 90-100

Satisfactory – 80-89 Unsatisfactory – 70-79

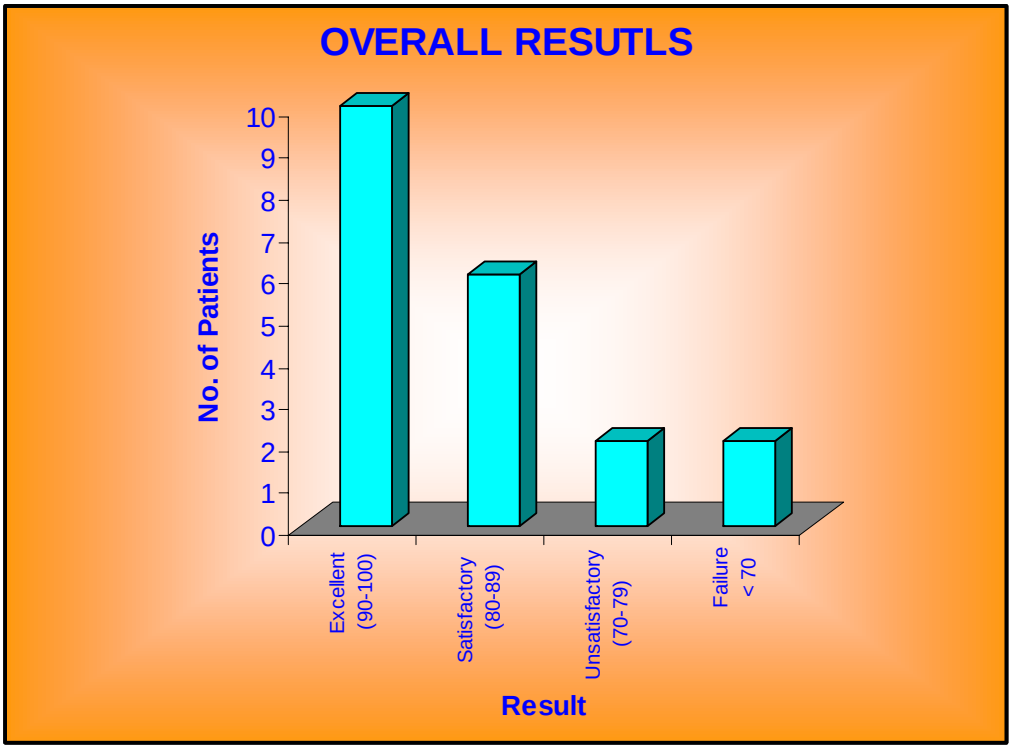
Failure - <70

Of the 20 cases 10(50%) patients had excellent result, 6(30%) satisfactory, 2(10%) unsatisfactory and 2 (10%) failure. [Table-XXIII]

TABLE–XXIII

OVERALL RESULTS

S.No	Rating	No: of Patients	Percentage
1	Excellent (90-100)	10	50
2	Satisfactory (80-89)	6	30
3	Unsatisfactory(70-79)	2	10
4	Failure< 70	2	10


OVERALL RESUTLS
No. of Patients
10
9
8
7
6
5
4
3
2
1
0
Excellent (90-100)
Satisfactory (80-89)
Unsatisfactory (70-79)
Failure < 70
Result

Illustrative Cases

ILLUSTRATIVE CASES

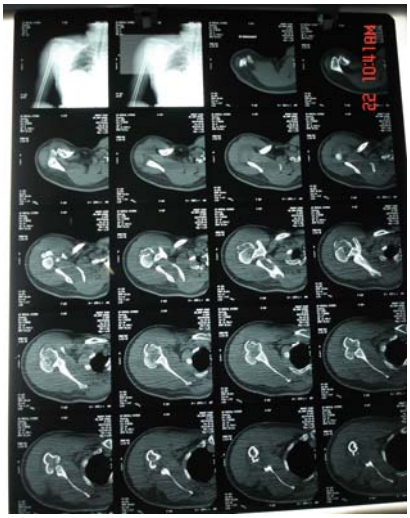
CASE 1

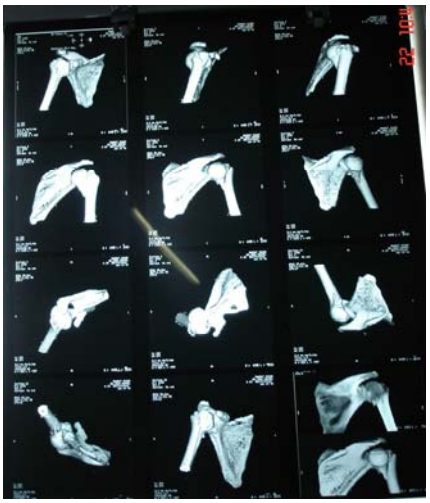
A 36 yrs old, Mr. G, an Right handed Tailor met with an accident and sustained a 4-part Fracture Right Proximal Humerus while he was travelling in a two-wheeler. He had # Metacarpal on the same side. Patient reported on the day of injury. Subsquently CT scan was taken to have complete view of fracture segments and 3D CT for complete understanding of anatomy. The patient underwent Percutaneous K-wire fixation 4 days after injury.

Post-operatively, the patient was Rehabililated with 3 Phase Rehabilitation Protocol of Hughes and Neer.

The patient was followed every 3 months. At 15 months followup patient has excellent functional result with no pain and is able to attend his original Profession.

ILLUSTRATIVE CASE I PRE-OP





ILLUSTRATIVE CASE I POST-OP

IMMED. POST-OP

1 MONTH POST-OP

6 MONTHS POST-OP

1 YEAR POST-OP

ILLUSTRATIVE CASE I CLINICAL PICTURES






CASE- 2

A 42yr old Mr. X, a Right-handed clerk sustained a 3-part fracture Right Proximal Humerus after he fell from ladder about 6m height, in his office. He was admitted 3 days after injury referred from private hospital with POP.

He underwent ORIF with cancellous screw with K wire Fixation through Deltopectoral approach 4 days after admission.

Post-operatively, the patient was started on pendulum exercise from Day 2 and supine external rotation exercises from 3rd week. K wires were removed 6 weeks after the surgery. Radiological study indicates features of malunion of greater tuberosity, but clinically the patient had fairly good range of movements that he was able to perform his day-to-day activities.

ILLUSTRATIVE CASE II

PRE-OP

IMMED. POST-OP

1 MONTH POST-OP

6 WKS POST-OP

ILLUSTRATIVE CASE II CLINICAL PICTURES

ILLUSTRATIVE CASE II CLINICAL PICTURES

CASE - 3

Mrs. X, a 56yrs old housewife who fell after slipping in her kitchen, sustained a 4-part fracture of Right Proximal Humerus was treated natively with splinting at nearby place. She got admitted in our hospital 10 days after injury and she underwent ORIF with LCP, 6 days after admission, controlling hypertension.

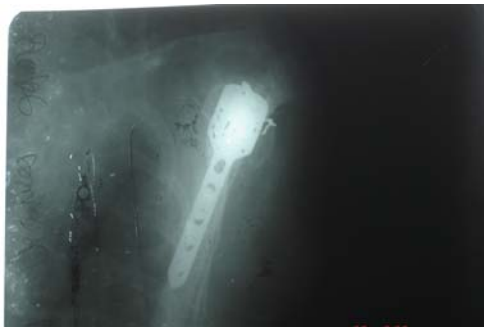
Post-operatively, the patient was rehabilitated with 3 Phase Rehabilitation protocol. The patient followup was for every 3 months, she had no complication. She was able to perform her day to day activities without any restriction and pain.

ILLUSTRATIVE CASE III

PRE-OP AP VIEW

PRE-OP LATERAL VIEW

IMMED. POST-OP AP VIEW



IMMED. POST-OP LATERAL

3 MON. FOLLOW-UP

ILLUSTRATIVE CASE III

CASE - 4

A 70yr old Mrs.Y , from Mylapore fell while walking on street and sustained 4-part fracture of Right Proximal Humerus without dislocation treated with POP at nearby hospital got admitted 3 days after injury with 3D CT taken.

She underwent Hemiarthroplasty and though she had mild pain, she was rehabilitated with hydrotherapy on 3rd postoperative day. Active and passive mobilization from 6th week. Then strengthening exercises from 10th week onwards. She had followup every 2 months upto 12 months, after which she was able to do normal optimum activities.

ILLUSTRATIVE CASE IV

CASE- 5

A 46 yr old female labourer fell from height while building house and she sustained 3-part fracture Right Proximal Humerus associated with fracture distal Radius on the same side, got admitted 2 days after the injury.

The patient underwent ORIF with Plate osteosynthesis with 'T' Buttress plate. Postoperatively the patient had skin necrosis for which antibiotics was given and she responded The patient was Rehabilitated with 3 Phase Rehabilitation Protocol of the Hughes and Neer.

The patient was followed up every 2 months until 12 months that the patient had excellent result that she able to perform her job with ease

ILLUSTRATIVE CASE V X-RAYS

PRE-OP AP VIEW

PRE-OP LATERAL

1 YEAR FOLLOW-UP AP

1 YEAR FOLLOW-UP LATERAL

ILLUSTRATIVE CASE V CLINICAL PICTURES

CASE - 6

A 36 yr old Bank employee Mr. X, met with accident while he was going to his bank in two-wheeler and he sustained 2 part fracture of Right Proximal Humerus got admitted on the same day of injury.

The patient underwent ORIF with cancellous screw through Deltoid Splitting approach 3 days after injury.

Postoperatively, the patient had no complications and the Rehabilitation started on from the 2nd day with pendulum exercises and continued with the Rehabilitation Protocol as such. The followup for every 3 months done and at 12 months the patient was found performing his day to day activities efficiently.

ILLUSTRATIVE CASE VI X-RAYS

PRE-OP

6 MONTHS POST-OP

CASE - 7

A 54yr old House-keeper, while crossing the road was hit by a bike and she sustained 2 part fracture of Right Humerus with Dislocation was admitted on the next day. There were no associated injuries.

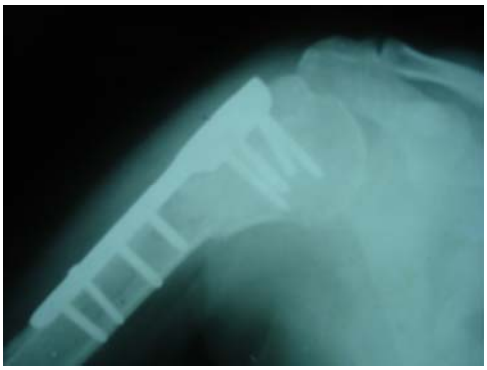
She underwent ORIF with LCP, through Delto-pectoral approach and postoperatively the patient was on pendulum exercise from day 2 and supine external rotation exercises from 3rd week. The patient was followed up as per protocol. At the 8 month, the result was excellent that she was able to perform her work with ease.

ILLUSTRATIVE CASE VII

Mrs. D. PRE-OP

IMMED. POST-OP

3 MON POST-OP LATERAL



3 MON POST-OP AP

Discussion

DISCUSSION

In this study we have analysed 20 cases of surgically managed Proximal Humerus Fractures in our hospital. There was female preponderance in our study 12 (60%) a study conducted by Hawkins & Bell involving 15 patients of Proximal Humeral Fractures there was female preponderance. In Kristiansen et al study of 565 PHF in 5,00,000 people 77% of fracture in all age groups involved were women. This is thought to be a result of advanced osteoporosis.

In our study the average age of the patients was 46.3 years which was lower than reports by Hawkins and Gurr[28] and Flatow et al[74] and Cornell CN, Levine D S, Pagnani M J[75].

Free fall at ground level was the most common mode of injury & fall on outstretched hand was the most common mechanism of injury & average age 46.3 years in our study, much in comparison with the study by Flatow et al[74] as fall on the arm was the predominant mode of injury & average age of the patient (53 mean) in their study. Since our people attain menopause early and have poor bone quality the average age is lower.

In our study, unusual mode of injury like seizures was present in one patient.

The Neer Classification is the most widely used scheme for Proximal Humeral Fractures. It has gained wide clinical acceptance by orthopaedic surgeons and radiologists and is considered to have important implications for both treatment options and outcomes. We also have followed the Neer's four part classification in our study but several authors have reported low level of interobserver reliability. Sidor et al[17] reported a reliability co-efficient of 0.48 for 1 viewing and 0.52 for 11 viewing and reproducibility co-efficient of 0.66.

In order to properly employ this classification, precise radiographic evaluation is of paramount importance[56]. We have found the Neer's three view trauma series to be of greatest value in evaluating these fractures. The importance of these series has been shown by Richard J, Hawkins S and R.L. Angel[76].

Computed tomographic scans were done in patients who had equivocal findings and also to find the direction of dislocation. Flatow et al[74] believed that sole reliance on standard AP radiograph may lead to under estimation of the amount of displacement of fragments.

There was a predominance of two part fracture in our study (50%), of which greater tuberosity fracture were the most common. Associated dislocations were present in 40% of the patients. In the reduction of glenohumeral dislocation if tuberosity fragment remained displaced >1 cm or angulated more than 45°, ORIF was

done. Repair in such patients restored the dynamic stability by reattachment of the muscles of the rotator cuff[74].

Flatow et al[74] in a series of 12 patients reported 50% excellent results and 50% good results in patients treated by ORIF for two part greater tuberosity fracture.

Closed treatment of three part fracture is associated with moderate pain, poor motion and disability. ORIF was associated with good to excellent results in more than 80% of patients in a report by Hawkins et al[56] and recommended operative treatment for healthy active individuals who have three part fractures of the Proximal Humerus. Cornell and Levine[75] reported good results with screw tension band technique for 3 part fractures.

Prosthetic replacement for 3 part fracture has been used by several authors but we have not used prosthetic replacement for three part fracture in our study.

In the treatment of four part fracture and fracture dislocations, less than 10% good or excellent results are obtained by either closed or open reduction or internal fixation. Isolated reports of revascularization of humeral head following open reduction and internal fixation indicate satisfactory healing.

Unfortunately, many of the cases referred in the literature often have not been true four part fractures with isolation of articular fragment and follow-up is not sufficient to rule out long term osteonecrosis. Hugg and Lundberg noted 74% AVN when ORIF was used for these fractures. AVN is reported to be as be as high as 90% in four part fractures and 3-25% in 3 part[4,77].

All authors agree that pain relief has been greater than 90% with prosthetic replacement, but there has been varying results with regard to function, motion and strength. Neer and McIlveen have reported nearly 90% excellent results with an improved technique utilizing long deltopectoral approach and better rehabilitation.

From the data presented in this study we have demonstrated that majority of the patients had no pain or only mild pain (80%) which is comparable to the study by Hawkins et al[56] and Flatow et al[74].

The average active elevation in our study in two part fractures was 127.75° and average external rotation was 47° which is comparable to the study by Flatow et al[74] in a study of 12 patients of two part fractures treated surgically.

The average elevation in our study with three part fracture was 124.0625° and external rotation was 45.3° which is also comparable to

the study by Hawkins et al[56] of 15 cases of 3 part Proximal Humerus fractures treated surgically.

Of the 10 patients with 3 part and 4 part fractures 8 patients (80%) regained atleast 90° abduction and elevation.

About 90% of the patients had full muscle strength which is also comparable to the study by Hawkins et al[56] and Flatow et al[74].

We have seen few complications in our study. Malunion of greater tuberosity fragment in a patient with 3 part fracture treated with cancellous screw with 'K' wire resulted in restriction of abduction and impingement. Good functional results are seen reflecting the fact that radiological outcome may not imply functional outcome.

Heterotopic ossification occurred in one patient with 4 part fracture dislocation, probably because the patient had exercised native treatment in the form of many attempted reduction and massage. Several authors have reported an incidence of upto 10% of heterotopic ossification in proximal humeral fractures[79].

There was no non-union or radiographic evidence of a vascular necrosis or deep infection in our study.

Finally a prolonged closely monitored and well defined program of rehabilitation was necessary to obtain the best functional results. We have followed the three phase rehabilitation protocol of Hughes

and Neer in all our patients and this has provided good results. For some patients this had taken as long as a year to achieve nearly full range of motion and function.

LCP results: The mean constant score in our study with 4 patients was 77.47 with is about equal to the study by Koukakis et al[78].

In summary fractures of Proximal Humerus may be extremely demanding. There are many pitfalls for the unwary patient and surgeon to avoid during the course of treatment. Emphasis is placed on complete and accurate diagnosis and formation of safe and simple techniques for restoration of disability, fracture healing and cuff integrity, motion and strength.

Conclusion

CONCLUSION

- Displaced proximal humeral fractures when treated surgically produce less pain, less stiffness and greater ROM.
- Earlier the surgery better are the results.
- In severely comminuted fractures where anatomy cannot be restored without extensive soft tissue dissection, fixation with K wires and screws gave better functional results.
- Results are better with fractures than with fracture dislocations.
- Results are best when operative method results in stable fixation that allows early passive mobilization.
- Functional outcome of 2 part fractures is better than 3 part and 4 part fractures.

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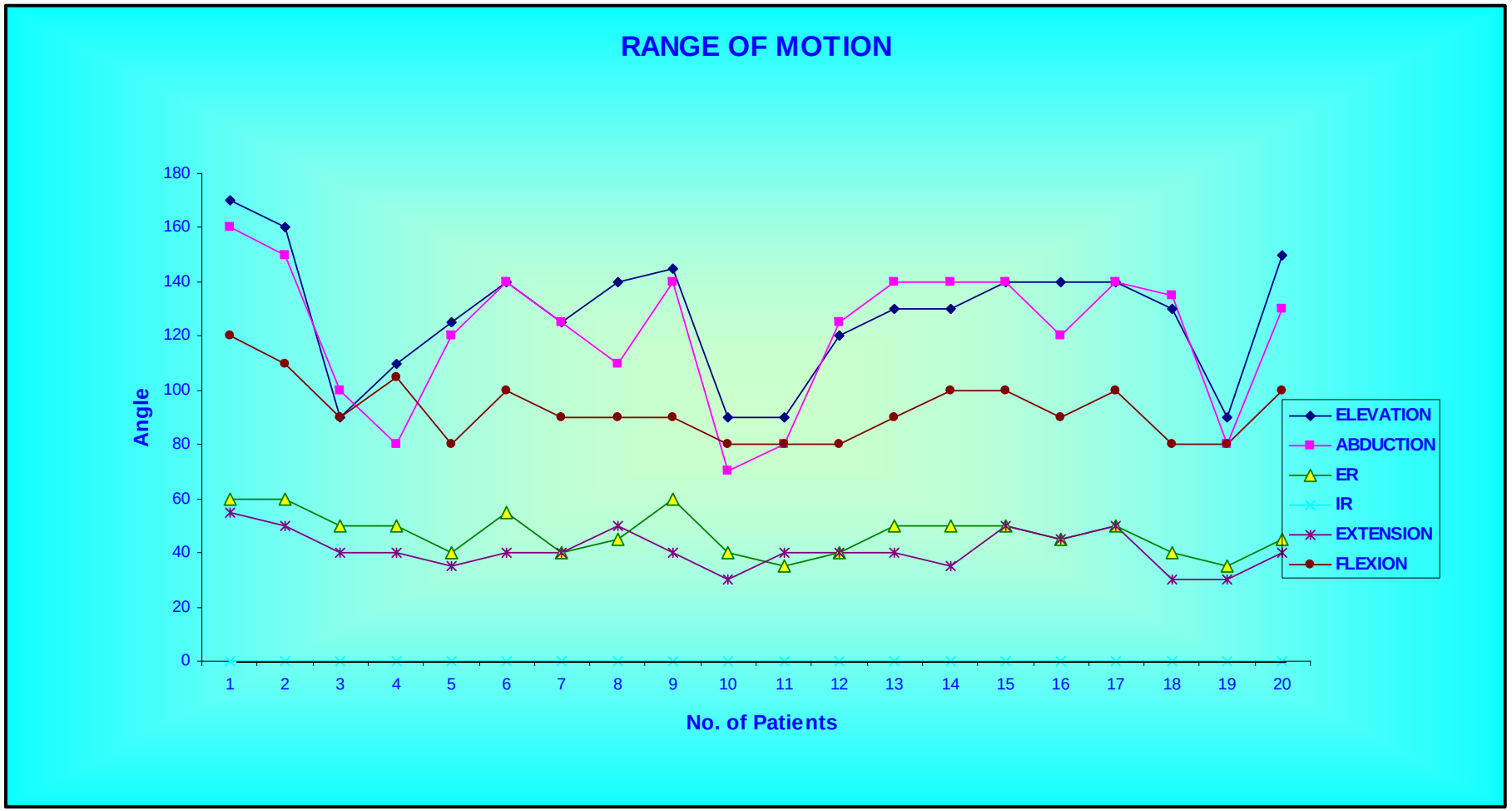
Master Chart

S.no	Age	Sex	Occupation	DOI	DOA	DOS	MOI	Type	Dislocation	Side	Unilateral/ bilateral	Asso. Injury	Previous treatment	Open/closed	Days inj AD	CT	3D CT
1	16	M	Student	01/06/04	01/06/04	04/06/04	RTA	2 part	N	L	UL	# SOH		C	0		
2	24	M	Dentist	10/07/04	10/07/04	14/07/04	RTA	2 part	N	R	UL	# MC		C	0		
3	65	F	Housewife	10/08/05	20/08/05	26/08/05	FAG	4 part	N	R	UL		splinting	C	11		
4	42	M	Clerk	11/10/04	14/10/04	18/10/04	FFH	3 part	N	R	UL		POP	C	3		
5	50	F	Labourer	10/11/05	22/11/05	28/11/05	FAG	4 part	yes	R	UL		ARM	C	12	Y	
6	27	F	Typist	08/01/05	08/01/05	24/01/05	EPILEPSY	2 part	yes	L	UL			C	0		
7	57	F	Housewife	06/01/06	07/01/06	18/01/06	FAG	3 part	yes	R	UL			C	1	Y	
8	36	M	Tailor	12/02/05	12/02/05	16/02/05	RTA	4 part	N	R	UL	# MC		C	0	Y	Y
9	29	M	Plumber	03/03/05	03/03/05	07/03/05	FFH	2 part	yes	L	UL			C	0		
10	35	F	Labourer	29/04/05	07/05/05	13/05/05	RTA	2 part	N	R	UL	# Scapula	splinting	C	8		
11	70	F	Housewife	15/06/05	18/06/05	22/06/05	FAG	4 part	N	R	UL		POP	C	3	Y	Y
12	60	F	Housewife	02/07/05	05/07/05	11/07/05	FAG	3 part	N	R	UL	# NOF	Massage	C	3	Y	
13	46	F	Labourer	07/07/05	09/07/05	13/07/05	FFH	3 part	N	R	UL	# DR		C	2		
14	48	F	Teacher	02/08/05	02/08/05	05/08/05	FAG	2 part	yes	R	UL	# BB FA		C	0		
15	38	M	Bank employee	11/10/05	11/10/05	14/10/05	RTA	2 part	N	R	UL			C	0		
16	63	M	Retd.	24/11/05	24/11/05	28/11/05	FAG	2 part	N	R	UL			C	0		
17	54	F	House-keeper	05/12/05	06/12/05	12/12/05	RTA	2 part	yes	R	UL			C	1		
18	58	F	Housewife	17/01/06	17/01/06	23/01/06	FAG	4 part	yes	R	UL	# DR		C	0	Y	Y
19	55	M	Business	14/02/06	14/02/06	20/02/06	RTA	3 part	yes	L	UL			C	0		
20	53	F	Housewife	24/02/06	28/03/06	06/03/06	FAG	2 part	N	R	UL		Massage	C	4		

Sl. No	Days inj to surgery	APPROACH	IMPLANT	Follow up	Elevation	Abduction	ER	IR	Extension	Flexion	Pain	Skin Necrosis	Wound Graping	Nonunion	Malunion	JT Stiffness	HET.Ossification	Deltoid Atony	Instability	Axilary nerve damage	Infection	Grade	Constant Score
1	3	DP	TBW	24	170	160	60	T 3	55	120													88
2	4	P	K WIRE	24	160	150	60	T 4	50	110													86
3	16	DP	LCP	11	125	120	50	L 1	40	90													86
4	7	DP	CSK	20	110	80	50	L 4	40	105					Y								72
5	18	DP	LCP	10	90	100	40	L 4	35	80	PR					Y	Y						60
6	16	DP	T	15	140	140	55	T 6	40	100													88
7	12	DP	LCP	8	125	125	40	L 1	40	90	PUA												76
8	4	P	K WIRE	15	140	110	45	T 5	50	90													86
9	4	DP	CST	15	145	140	60	T 4	40	90	MILD												78
10	14	DS	CS	12	90	70	40	T 12	30	80	MILD							Y	Y	Y			55
11	7	DP	HEMI	12	90	80	35	L 2	40	80	MILD												60
12	9	DP	TBW	12	120	125	40	L 1	40	80	MILD												75
13	6	DP	T	12	130	140	50	T 10	40	90		Y											86
14	3	P	K WIRE	10	130	140	50	T 8	35	100													86
15	3	DS	CS	10	140	140	50	T 6	50	100													90
16	4	DS	K WIRE	8	140	120	45	L 1	45	90	PUA												76
17	7	DP	LCP	8	140	140	50	T 9	50	100													88
18	6	P	K WIRE	6	130	135	40	L 2	30	80	MILD												76
19	6	DP	T	6	90	80	35	L 3	30	80	PR		Y			Y							54
20	10	P	K WIRE	6	150	130	45	T 8	40	100													86


RANGE OF MOTION
Angle
180
160
140
120
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
No. of Patients
ELEVATION
ABDUCTION
ER
IR
EXTENSION
FLEXION

ABBREVIATION

DOI	-	Date of Injury
DOA	-	Date of Admission
DOS	-	Date of Surgery
MOI	-	Mode of Injury
RTA	-	Road Traffic Accident
FAG	-	Fall at Ground Level
FFH	-	Fall From Height
#SOH	-	Fracture Shaft of Humerus
#MC	-	Fracture Metacarpal
#NOF	-	Fracture Neck of Femur
#DR	-	Fracture Distal Radius
#BB FA	-	Fracture Both Bones Fore Arm
POP	-	Plaster of Paris
ARM	-	Attempted Reduction & Massage
ER	-	External Rotation
IR	-	Internal Rotation –Spine Level
DP	-	Delto Pectoral
P	-	Percutaneous

DS	-	Deltoid Splitting
TBW	-	Tension Band Wiring
‘K’ wire	-	Kirschner Wire
CSK	-	Cancellous Screw and ‘K’ Wire
LCP	-	Locking Compression Plate
CST	-	Cancellous Screw and TBW
CS	-	Cancellous Screw
HEMI	-	Hemiarthroplasty
T	-	‘T’ Buttress Plate
PR	-	Pain at Rest
PUA	-	Pain with Unusual Activity
MILD	-	Mild Pain

Proforma

PROFORMA

Serial Number

Name

Age

Sex

Address

Occupation

IP No

DOI

DOA

DOS

MOI

Diagnosis

Classification

Investigation

- X-ray
- CT Scan
- MRI

Surgery

Implant

Rehabilitation

Complication

Follow-up

Evaluation

Evaluation form - Constant Score

CONSTANT SCORE TECHNIQUE

BACKGROUND

The **European Society for Shoulder and Elbow Surgery (ESSES)** adopted the scoring system of C Constant and A Murley. This scoring system consists of four variables that are used to assess the function of the shoulder. The right and left shoulders are assessed separately.

The subjective variables are pain and ADL (sleep, work, recreation / sport) which give a total of 35 points. The objective variables are range of motion and strength which give a total of 65 points.

SUBJECTIVE

Pain	15
ADL (sleep, work, recreation/sport)	20

OBJECTIVE

Range of motion	40
Strength	25

PAIN

Pain	Points
None	15
Mild	10
Moderate	5
Severe	0

ACTIVITIES OF DAILY LIVING

Activity Level	Points
Full work	4
Full recreation/ sport	4
Unaffected sleep	2

Positioning	Points
Upto waist	2
Upto xiphoid	4
Upto neck	6
Upto top of head	8
Above head	10

RANGE OF MOTION

Active range of motion should always be measured as part of the Constant Score.

ESSES recommends measuring range of motion with the patient sitting on a chair or bed, with weight even distributed between the ischial tuberosities. No rotation of the upper body may take place during the examination.

In the case of active motion, the patient lift his arm to a painfree level. Note that the number of degrees at which the pain starts determines the range of motion. If one measures the active range of motion with pain, this should be stated. The Constant score cannot then be applied beyond the initiation of pain.

The most important thing is that range of motion is performed and measured in a standardised way.

In the Constant score system there is precise information about how the points are calculated. Bear in mind that 150 degrees of flexion give 8 points, while 151 degrees give 10 points.

Forward flexion 10 points	
0-30°	0
31-60°	2
61-90°	4
91-120°	6
121-150°	8
151-180°	10

Abduction 10 points

0-30°	0
31-60°	2
61-90°	4
91-120°	6
121-150°	8
151-180°	10

External rotation 10 points (hand is not allowed to touch the head)	
Not reaching the head	0
Hand behind head with elbow forward	2
Hand behind head with elbow back	2
Hand on top of head with elbow forward	2
Hand on top of head with elbow back	2
Full elevation from on top of head	2

End of the thumb to lateral thigh	0
End of the thumb to buttock	2
End of the thumb to lumbosacral junction	4
End of the thumb to L3 (waist)	6
End of the thumb to T 12	8
End of the thumb to T 7(interscapular)	10

STRENGTH

Strength is given a maximum of 25 points in the Constant Score. The significance and technique of strength measurement has been, and continues to be, the subject of much discussion.

The European Society for Shoulder and Elbow Surgery measures strength according to the following method:

- A spring balance is attached distal on the forearm.
- Strength is measured with the arm in 90 degrees of elevation in the plane of the scapula (30 degrees in front of the coronal plane) and elbow straight.
- Palm of the hand facing the floor (pronation).

- The patient is asked to maintain this resisted elevation for 5 seconds.
- It is repeated 3 times immediately after another.
- The average in pound (lb) is noted.
- The measurement should be painfree. If pain is involved the patient gets 0 points.
- If patient is unable to achieve 90 degrees of elevation in the scapula plane the patient gets 0 points.

***FUNCTION MUSCLE (M)**

0 Less than 1 kg

3 "1 kg - 2 kg"

5 "2 kg - 3 kg"

7 "3 kg - 4 kg"

9 "4 kg - 5 kg"

11 "5 kg - 6 kg"

13 "6 kg - 7 kg"

15 "7 kg - 8 kg"

17 "8 kg - 9 kg"

19 "9 kg - 10 kg"

21 "10 kg - 11 kg"

23 "11 kg - 12 kg"

25 "12 kg or above"

SCORING

0-55	Poor
56-70	Moderate
71-85	Good
>86	Excellent